Eng. Lib.
JAN 10 1908

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1671

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1908, by Munn & Co.

Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

Scientific American, established 1845.
Scientific American Supplement, Vol. LXV., No. 1671.

NEW YORK, JANUARY 11, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE TRACTOR HAULING TWO FOUR-FURROW PLOWS AT TWO MILES AN HOUR.

DRIVING A LARGE 4 FOOT 6 INCH THRESHING MACHINE WITH 22 INCH DRUM. FUEL CONSUMPTION, 1.75 GALLONS AN HOUR, WORTH 21 CENTS.

A NEW AGRICULTURAL OIL MOTOR.—[See page 20.]

REINFORCED CONCRETE ENGINEERING.*

A REVIEW OF RECENT ADVANCES.

BY ALBERT WELLS BUEL.

Possibly the most far reaching, if not altogether the most important step in designing reinforced concrete structures, is the tendency toward making the steel elements alone form a complete and stable structure. The Thirty-ninth Street Building, New York, completed last year, is one example of this idea. If we have been correctly informed, the steel in the columns of this building was designed to carry all of the loads—the concrete being only considered as a protective covering as far as the columns are concerned. This, if so, is certainly on the safe side, but probably few will care to adopt such extravagant construction.

The writer has proposed a middle ground, not so costly as designing the steel for all of the loads on columns, but yet with all the advantages of a complete and stable steel frame, and perfectly safe. He would design the steel frame throughout, including all bolted connections, so that for all loads, including those due to erection, and without assistance from the concrete, no part of the steel would be stressed to over 32,000 pounds per square inch, nor over, say, 24,000 pounds per square inch for erection loads only, reduced, where necessary, by the usual formulas for flexure, etc. For the finished structure, no part of the steel should be stressed to over 16,000 pounds per square inch, reduced by formulas, where required, and the concrete should be limited to, say, 600 pounds per square inch in compression and 75 pounds per square inch in shear, except where there is an excess of steel.

Certainly the ratio of stress between the two elements in a compression member will be controlled by the ratio of their respective moduli of elasticity, and if it were not that the steel element, in a design of this class, may be given an initial load before the concrete is placed, there might not be sufficient advantage to justify it in comparison with designs of the building named. This is admittedly a complex feature of the principle proposed, and the only thing that can be said about it is that each case should be treated on its merits by qualified experts. Other "systems," however, have no less need of expert treatment—rather more—since the principle here outlined is intended to provide a steel frame that will be in stability for all conditions of loading irrespective of the concrete. The concrete supplies the protective covering and at the same time relieves the steel of excess load and stress.

Another recent example on this line is that shown in an illustrated communication from Mr. John M. Ettler in the Engineering Record of August 31, 1907, page 246. This describes the reinforcement of the Owl Drug Company's building on Mission Street, San Francisco, Cal., as follows: "The method of reinforcement marks an innovation in that the steel work forms a complete unit before any concrete is put in place. This unit is so completely formed that it is quite practicable to erect all steel work before any concrete is poured. Among the advantages of this method of construction, the following may be mentioned: The steel forms a complete structural unit in itself and does not cause internal stresses in the concrete, allowing the latter to perform the functions for which it was designed. Defects in the steel work cannot escape notice, and there is little likelihood of derangement of the steel during the pouring of the concrete. The design can be computed readily and permits very quick erection."

The Engineering Record of August 10, 1907, page 162, prints an illustrated description of "A System of Structurally Reinforced Concrete," patented, in which the complete steel frame is the main idea. This is encouraging, not only as an indication that a number of men are working for solutions of the problem along the lines herein outlined, but also because it permits us to hope that some will find it commercially profitable to exploit systems designed on safe principles.

Prof. Lewis J. Johnson, in a discussion at a recent meeting of the Boston Society of Civil Engineers, advocated the use of top reinforcement in beams and slabs, primarily to provide for the negative moment at the supports due to continuous beam action. (See Engineering Record of September 28, page 351.) That there is generally more or less restraint at the supports, and that it is often statically indeterminate, will be quite generally admitted, as will be the fact that in many cases no proper provision has been made for the negative moments. It is correctly pointed out that the top reinforcement is of the greatest possible value in case of weakening of bottom rods by fire. The top rods, through cantilever action, may carry the load after the far more exposed lower rods have failed. Irrespective of fire hazard, the top reinforcement increases the margin of safety, and may properly be taken into account in designing the section, thus effecting a saving of a part of its cost. If this principle comes to be generally adopted, it will greatly assist in the introduction of the complete steel frame system of reinforcement.

The most notable example of progress in methods of construction is furnished by the two new kiln houses of the Edison Portland Cement Company, at New Village, N. J., an excellent illustrated description of which is given in Engineering News for July 4, 1907, pages 5 to 9. These buildings were constructed entirely with separately molded members, cast on the ground from four to six weeks before being erected in place.

This method has been used to some extent in Europe, and reports of it have been favorable. Although we have in America one or two examples of Visintini construction, in which beams and girders are separately molded, the method has not as yet received the attention it seems to merit.

The experience gained with these buildings of the Edison Portland Cement Company will be very valuable to those contemplating the use of this method, particularly in regard to provisions and devices for safely lifting and handling the members. A device worthy of imitation is that of first casting the roof slabs on a cinder bed, to form the molding floor for the other members, afterward taking them up and setting them in position on the roof.

When the ground area for molding and casting the members near the building site is not available, the cost of transportation must be considered. It has been stated that it costs no more to transport the finished members than the cement and aggregates for concrete. The cost of the forms and of mixing and placing is considerably less than with monolithic work molded in place. It would also seem that labor conditions should favor the method of separately molded members.

The Engineering News states that the two buildings of the Edison Portland Cement Company will be finished at a total (estimated) cost approximately $4,000 less than two steel buildings of the same type. Some other advantages of the method are that the mixing and placing of the concrete are under more perfect control, resulting in a more uniform and reliable product. Tests to destruction may be made on extra members before the other members of the lot are erected in the structure. Test cubes or coupons may be made to represent as many of the batches or members as desired. The method permits close supervision and inspection. The concrete can be kept thoroughly wet while hardening, and no member need be erected until sufficiently aged, thus minimizing the danger of subjecting green concrete to stress. A rapid extension in the application of this method may be confidently expected.

Some intelligent efforts are being made to formulate rules, codes or specifications for design and construction in reinforced concrete. Those submitted to the Building Code Revision Commission of New York city by the Concrete Association of America, the new Building Code of San Francisco and "Some Essential Requirements in Reinforced Concrete Work" by Mr. Frank B. Gilbreth, Engineering News of August 29, 1907, deserve mention, notwithstanding that they are open to criticism on some points and seem to have failed to comprehend the full import of past experience (including some failures), and of recent experiments.

The report of the Joint Committee of British Architectural and Building Associations and government bureaus, together with its appendices, Engineering Record of July 27, and August 3, 1907, is more pretentious and perhaps more comprehensive. While some of its conclusions are quite different from what a similar American committee might be expected to arrive at, in view of the experience and experimental data available, others are somewhat in advance of the present practice here. The report begins with the sentences, "Reinforced concrete is used so much . . . that a general agreement on the essential requirements of good work is desirable," and, "Good workmanship and materials are essential. With these and good design, structures of this kind appear to be trustworthy." This would be all right, almost ideal, if there was any practical way to eliminate all bad designs.

The report states that "there is no reason to fear decay of the reinforcement in . . . cinder concrete made with clean, fresh water, if the metal skeleton be properly coated with cement." An article in Engineering News of May 23, 1907, page 569, by Mr. William H. Fox, gives results of experience and experiments showing serious corrosion in cinder concrete, and says, "A rich mixture, either a 1:1:3 or one in which the proportion of cement to aggregate is larger, should be used in all cases. The greatest of care should be taken in mixing the materials, and it may be necessary to resort to the seemingly impractical method of coating the reinforcement with grout before placing in the concrete. . . . It is quite evident that cinder concrete should be used only with a view toward the possibility of future corrosion."

The report gives considerable attention to the question of fire resisting qualities, and to materials and proportions. Of the three highest fire resisting materials recommended for the aggregate, slag will undoubtedly give the strongest and best concrete.

The specification for sand is about the best that has been proposed. All sand is required to pass a ¼-inch mesh and 75 per cent of it a ⅛-inch mesh. It is required to be clean, but washing, it says, does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process. Sand briquette tests, it points out, are better than mere appearance in judging the value of a sand. It recommends that the aggregate pass a ¾-inch mesh and be retained on a ¼-inch mesh.

The proportions of cement to sand and aggregate must be such that the cement at least equals the voids in the sand and gives the required strength and that the mortar be at least 10 per cent more than the voids in the aggregate. It recommends that the voids in both sand and aggregate be measured as well as the "volume of mortar produced by the admixture of sand and cement in the proportions arranged." This is by far the best specification on these points that has yet been published in complete form. The writer has used a similar method for ten years.

An allowance for shock is recommended, equal to half the accidental load for public halls, factories, etc., and equal to the accidental load for floors carrying machinery, the roofs of vaults carrying passage ways and courtyards.

In view of American experiments as well as of the Hyatt-Kirkaldy tests, undue importance seems to be given to bending up the ends of rods and other forms of end anchors.

For high steel one-half the stress at the yield point is recommended as the allowable tensile stress. This will permit some rather high working stresses, but, with the provision of allowances for shock, they are probably justified.

Of the appendices, that written by Prof. A. C. Unwin on slab theories will, no doubt, receive the most attention in this country, where this subject has already become a live topic for discussion. Prof. Unwin compares Grashof's and Rankine's rule with the French government rule and with Bach's theory, but an entirely satisfactory solution has not yet been presented. Bach's theory does not seem to give uniformly distributed reactions. It appears to require the reinforcement to be perpendicular to the diagonals.

The Grashof-Rankine and French government rules are applicable to slabs with reinforcement parallel to the sides and ends, that is, transverse and longitudinal. This would seem to imply reactions greater at the centers of the sides and ends than at the corners, and greater for the long sides than for the short ends. With transverse and longitudinal reinforcement, it is not clear how an element can receive any increment of load or moment on the central part of its length intercepted by the diagonals of the rectangle. This, of course, refers to uniformly distributed loads only.

If the reinforcement were arranged parallel to the diagonals, each of the sides and ends would appear to have the same amount of reaction and uniformly distributed from corner to corner, the intensity along the ends being greater than along the sides in the inverse ratio of their lengths.

It is probable that smaller rectangles, with diagonals coincident with those of the slab, will mark lines of equal deflection and that, therefore, the part of the

* Abstracted from a compilation by Technical Literature.

length of elements coincident with a side of such inscribed rectangle will not be subject to increment of load or moment.

The authoritative solution of this problem seems to require the attention of the laboratories and theoretical investigators, and, for the present, the best plan for the ordinary constructor to follow is to make his slabs safe. The Grashof-Rankine rule is more conservative than the others, and is applicable to the usual case of transverse and longitudinal reinforcement. For reinforcement on lines parallel to the diagonals, or perpendicular to them as indicated by the Bach theory, the form of expanded metal disposes the reinforcing metal very nearly on theoretical lines.

Where the length of the slab exceeds twice its width, it should be designed as a simple beam for a length of span equal to its width.

TANNERY WASTES.

THEIR PRACTICAL UTILIZATION.

UTILIZATION of the Waste as Fertilizer.—There is a certain prejudice against the employment of exhausted tan-bark as a fertilizer, on account of the tannin it contains. This, by the formation of tannic acid, may certainly prove injurious to cultivated plants. We must, however, remember that all tan bark used for tanning purposes is completely exhausted. In a recent article, this objection is opposed by practical illustrations.

The tanning process, it is therein stated, results in a number of wastes and residues which are capable of unlimited utilization, especially in agriculture, to a much greater extent than has hitherto been supposed. These wastes are naturally to be classified as animal and non-animal. The farmer, however, can only utilize to advantage the wastes of both classes that cannot be usefully employed for any other purpose, because he cannot pay the price for his fertilizers that other interests, that produce directly from these wastes something that is utilizable, are in a position to pay. The animal wastes of tanneries are much richer in fertilizing substances than the non-animal kind. In tanneries, the fresh, green hides are first of all exposed for a lengthy period to the effects of lime milk and are then subjected to two processes that impart to tannery wastes their value. First of all, the hair is removed from the outer surface and remains for a long time in contact with the lime milk. The second manipulation effects the removal of the fleshy particles from the inner side of the skin and at the same time of the thin cuticle. These residues are mixed together and remain piled up in a heap. They contain, on an average, the following approximate constituents: about 75½ per cent of water, 24½ per cent of dry substance. The dry substance consists of 84½ per cent of organic matter and 15½ per cent of mineral substances.

In 100 parts of the latter, there are to be found 3¼ per cent of silicates, 17½ per cent of phosphate of lime, 69 per cent of carbonate of lime, and in addition 10 per cent of various salts. The average quantity of nitrogen is about 7 per cent. As a rule, these heaps are allowed to accumulate for two to three months, within which period they lose about one-fifth of their volume of water and three-tenths of their nitrogen. These losses are due to the rapid decomposition of the animal substances under the influence of lime. This fertilizing material then has, according to the prevailing price of its chief constituents, a considerable value. In strawberry beds, the earth is covered say about two inches deep with spent tan, which insures a clean bottom under the fruit. The chief enemies of the strawberry, snails, are at the same time kept away.

The vegetable portion of this tannery waste is a result of tanning which is only obtained after the first treatment of the hides. This process is conducted by the employment of oak or other tree barks, rich in tannin, which are finely ground or crushed and disposed in alternate layers between the hides in the tan pits, after which water is admitted to dissolve the tannic acid.

The fibrous and spongy character of the tan barks or the so-called tan used, first inspired the idea as to whether this otherwise worthless material was not adapted for use in place of straw, for litter.

Used as litter, tan absorbs more than twice its weight of fluid and it is desirable therefore to use it for this purpose, in combination with straw-litter. It is not heavy and can, therefore, be easily transported. Nevertheless, the tan still contains some tannic acid and it is advisable therefore to use it in combination with lime or phosphates or ashes, materials which at the same time accelerate its decomposition; together with the animal wastes, therefore, tan makes an excellent fertilizer. In the garden it prevents, in the most effective manner, evaporation and the drying out of the soil.

Finally, we are familiar with the utilization of tan bark as tan-briquettes, with the aid of a pressing machine, these cakes serving for use as fuel. Tan bark, on account of its elasticity, is also used for covering the floors of gymnasiums, riding schools, etc.

The waste water from tanneries, in its use as a valuable fertilizing material, is especially commended by Jackson S. Schultz. We note as follows his remarks on the subject as communicated by Franz Kathrenier, of Munich, in the Gerber Zeitung:

Not only the steeping water but also the used-out liquor and pit materials, and finally the rinsing water from the fleshings and purifiers, should be finally collected in a reservoir built below the foundations of the tannery, so that all these valuable fertilizing mediums may be brought together, without the employment of any pumping apparatus. This reservoir may be located at a distance from the cleaning and scraping department; as a matter of fact, it is preferable to locate it at a distance of several hundred feet, rather than near by. It should be spacious enough to contain, not only the waste water, but all the solid matter from the sweepings and cuttings on the floors of the cleaning department and the dry storage. These waste waters are so valuable that the writer can easily understand how a small tanner can make 100 acres fertile, by the waste from a business of 5,000 hides. Old spent tan bark, scrapings and even earth, may be carted to and deposited in this fertilizer reservoir to take up the ammonia and then very profitably spread on the land.

The waste in the shape of pieces of bare skin, and also of tanned leather, may be employed in the production of an excellent material for the preparation of fine glue-stock. Owing to the diversity of the material, the scraps of hides and leather are collected in separate vessels. Wastes of tanned leather, provided that they have been thoroughly dried by being spread in thin layers, may be preserved, without further trouble, in any kind of vessel, until a quantity sufficient to pay for the trouble has been collected.

Scraps of untanned hide can be treated in the same manner; but the drying is not undertaken because the bare scraps, impregnated with water, are in just the condition to be readily transformed into glue. The glue manufacturer would have to re-steep the dried waste, which would entail waste of labor. The hide scraps are therefore left in their steeped condition, only taking care that they are not exposed to putrefaction. This is accomplished by collecting them in a tub containing clear lime water. Care must be taken, however, that the scraps are always immersed and that sufficient lime is present. To insure this, add from time to time fresh lime water. If the tub containing the scraps is set up in a cool place, the scraps of hide may be kept from 4 to 6 weeks, without decomposing; if the scraps are then to be worked into glue, the lime water is run off and they are washed a few times, with clean water.

Still more convenient than this process is the preservation of the hide scraps in a weak solution of carbolic acid—1 to 1,000. When the scraps are to be used, it is only necessary to remove them from this solution, allow them to drain thoroughly and wash them in water. The carbolic acid solution may be used for the preservation of new supplies of hide scraps.

Scraps of skin can be worked into glue without any preliminary treatment. Scraps of tanned leather are best washed repeatedly with cold water; later treated with warm water to remove the tannin and as far as possible to start the retrograde formation of depilated skin. Scraps of chamois leather can only be transformed into glue with great difficulty, because the tanning substance is more thoroughly incorporated in them than in tanned leather; the best way is to boil such wastes with a weak caustic lye, by which means they are at least in part deprived of their tannin.

To utilize for glue the scraps of leather tanned with alumina soaps, they must first be boiled in a fluid containing acid; sulphuric acid, for instance, to decompose the insoluble soap, then washed out and boiled with a weak caustic lye, so that the fatty acids contained in the scrap can be reduced to soluble form.—From the German of Theodor Koller in Verwerthung von Abfallstoffen aller Art.

A report of the Commissioner of Mines published in a recent issue of the Eisen-Zeitung gives an account of a discovery of copper in British East Africa, in the valley of the Tsavo River. The most important find is about 70 kilometers west of the Tsavo station. The ore is both native copper and sulphide in a large quartz reef, which runs from the foot of Mount Kiulu southeast through the valley. Its extent has not yet been determined. In addition to the copper, there are traces of gold, and platinum is also suspected. The assay is said to show 30 per cent copper in the reef.

EXPERIMENTS WITH ELECTRICAL TREATMENT OF BOILER WATER ON THE EL PASO & SOUTHWESTERN RAILWAY SYSTEM.*

By J. L. CAMPBELL.†

THE worst wells on our road are east of El Paso. After we have treated these exceptionally bad waters, which cover a distance of 128 miles on the Eastern Division, they are still of bad quality, and as a result our engine tonnage is reduced 25 per cent, and the excess annual maintenance on locomotives is approximately $1,000 per year per engine. Generally we cannot reduce the incrusting solids in these bad waters below 20 grains per gallon without producing an inadmissible amount of foaming; consequently, we have exhausted the practicability of the lime and soda ash treatment.

During the past year we have been experimenting with the electrical treatment of some of these waters. At Alamogordo we reduced the incrusting solids from 40 grains to an average of 6 grains per gallon, and at Pastura from 140 to 30 grains. It was possible to still further reduce the Pastura water by increasing the intensity of the electric current and the time of treatment, but we have ascertained that the electrical treatment is impracticable on account of the excessive cost, which has run as high as $1 per 1,000 gallons, for the worst waters if treated down to 10 grains and less per gallon.

The method of treatment consisted in submerging aluminium or iron plates in the water to be treated, and passing an electric current through the plates, which were suitably connected up in series. The experimental treating plants consist of a series of wooden vats, each of which is divided into a number of compartments, each compartment containing a large number of aluminium or iron plates set on edge in grooves and spaced from ½ inch to 1 inch apart. In one of the plants the water flowed continuously by gravity through the vats. In the other the vats were filled and the water remained stationary until treated, when it was emptied and the vat refilled. For a number of reasons the intermittent treatment would probably be the more practicable in continued use. The aluminium plates experimented with were about 12 inches wide and 3 feet long; the iron plates are about 3 feet square. Both kinds of plates are dissolved in proportion to the amount of water treated, and we find the expense of the renewal of plates is a very large item in the cost of treatment. As a result of the experiments, our conclusions are that the electrical treatment is not practicable on account of the cost and the large amount of work involved in the daily operation, cleaning and maintenance of the experimental plant.

On the division of the road above specified, where the waters are so bad for a distance of 128 miles, we have adopted a very radical remedy, which consists of bringing water by gravity from the White Mountains to and along our railway for a distance of 130 miles by means of a combined gravity pipe line and two pumping plants to lift the water over a divide between the Rio Grande and the Rio Pecos drainage areas. The water from the White Mountains is of a very superior quality, averaging about 5 grains incrusting solids per gallon. This pipe line will eliminate all of the present water supply, which cannot be successfully treated with lime and soda ash; in fact, it will eliminate all of the treating plants we now have, with one exception. The estimated cost of this supply of pure mountain water is $1,300,000, but we find that its capitalized value will be several times that amount, from which the seriousness of the water condition in the past can be judged.

Our present water supply in question has an annual charge against it of 98 cents per 1,000 gallons, which includes charges for reduced train tonnage, the excess annual repairs to locomotives and incidental impairment to the efficiency of the service generally. We estimate that the pipe line supply of water will carry an annual charge of 16 cents per 1,000 gallons.

* Abstract of a paper in Bulletin No. 91 of the American Railway Engineering and Maintenance of Way Association.

† Engineer of Maintenance of Way, El Paso and Southwestern Railway, El Paso, Tex.

A NEW AGRICULTURAL OIL MOTOR.

THE POSSIBILITIES OF THE KEROSENE ENGINE ON THE FARM.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

WITHIN recent years several developments have been carried out in the use of mechanical energy for agricultural purposes, one of the most important of which has been the use of the automobile in various forms on the farm. The tendency has been toward the evolution of a small, powerful, comparatively light type of tractor, capable of superseding the horse and the general class of traction engine, but with a wider range of action, so that it can be used not only for the more difficult farming operations, such as plowing, cultivating, and reaping, but when not so required can be utilized for ordinary haulage purposes at a comparatively high speed, and the driving of auxiliary agricultural machinery, such as threshing machines, chaff cutters, and so forth.

A very efficient and handy oil motor of this type has recently been introduced in England. It possesses several novel features, and seems to have proved a highly successful all-around acquisition to the farm. The general design of the oil tractor may be gathered from the accompanying illustrations. The two-cylinder motor, which is of the water-cooled vertical type, is mounted centrally upon a strong channel steel frame and develops from 30 to 35 horse-power at 860 revolutions per minute. The valves are placed on top of the cylinders to facilitate access, and are operated by means of crank levers from the cam shaft, which in turn is driven by spiral gearing and a vertical shaft from the engine crankshaft. The circulating pump is similarly gear driven. The engine has throttle control, the governors being of the ordinary bell pendulum type. Forward of the engine is the water cooler, which is of novel design. In such tractors one of the greatest difficulties to be surmounted is in connection with the cooling, since unlike a pleasure automobile it always travels at a comparatively slow speed, so that the air draft is insignificant. With the conventional radiator system the water is always in a semi-boiling condition, so that the engine is apt to run hot. In order to overcome this difficulty, water cooling is carried out upon a modified cooling tower system. The heated water passes from the cylinder jackets to the finned surface at the top of the rectangular chamber. From this point it falls in a fine spray upon a series of corrugated plates alternately inclined at opposite angles, the spray thus zigzagging from the top of the cooler to a tray at the base, where a depth of three inches of water is maintained. As the water thus falls it is brought into contact with an upward blast of cold air, this draft being produced by the suction of the exhaust gases from the engine. The gases are discharged into the base of the vertical muffler surmounting the cooler, at the base of which muffler is a small annular space, through which the upward draft of cold air is induced from beneath the engine, zigzagging upward through the cooler, and escaping with the exhaust gases into the air through the muffler. By this arrangement, no matter how slow the motor may be working, the heavy load factor, and the prolonged length of time it may be kept running, it never becomes overheated. The water supply is carried in a tank beneath the driver's seat, and being of 70 gallons capacity, will last the engine for several days without replenishment, while similarly sufficient oil fuel can be carried in one charge for three days' work.

The motor is designed to work upon heavy fuel, such as kerosene, since such a fuel is more readily obtainable than the more volatile gasoline, while it is also considerably cheaper. In order to insure the efficient vaporization of the liquid, a special type of carbureter has been designed. The oil enters the vaporizer through a small valve controlled by a piston, and as it passes through this valve it meets with a current of air. This mixture then comes into contact with heat produced by the exhaust gases of the motor, passing through a small box the top and bottom plates of which are corrugated so as to secure a larger radiation surface, and this heat is sufficient to vaporize the kerosene, which in its gaseous state combines with the air. The mixture is then drawn up into the combustion chambers of the motor. The engine is first started up on gasoline, a small supply sufficient for several days being carried. Directly the motor is started, the gasoline supply is cut off and the heavier fuel is switched on. This vaporizing system, which is the outcome of several years' experiment, has proved eminently successful. Low-tension magneto ignition is fitted with spark-advance control.

The engine power is transmitted through a clutch to the change speed mechanism, which is of the gear-wheel type, there being no chains whatever. Three speeds are fitted, 2, 4 and 6 miles per hour respectively forward, with reverse on the lowest speed. These have been found adequate for any phase of agricultural requirements. Ample braking is provided, there being the ordinary foot pedal acting on the driving shaft brake, and a powerful screw hand brake acting upon the rear wheels. On one end of the crank shaft—the engine is set transversely in the frame—a pulley for driving by belt any kind of machinery, such as threshers, chaff cutters, pumps, dynamos, milk machinery, etc., when stationary, is fitted, and the tractor can quickly and easily be set in position in line facing the plant to be so driven.

The rear wheels, being the driving wheels, are of substantial construction, and are built up with a steel rim and iron spokes with steel bosses lined with heavy brass bushes. The tires are of the ordinary traction engine type, in order to secure a firm purchase upon slippery soil. The front wheels are of similar construction, only lighter, and the steering is carried out upon the usual automobile lines with hand wheel and worm gear. The complete weight of the tractor loaded ready for service is 4¼ tons, the weight being well distributed over the four wheels.

In regard to cost of operation, some interesting trials have been carried out. For general haulage purposes upon the highroad the tractor will haul a load of 10 tons up a gradient of 1 in 20 on the second speed at 4 miles per hour, and with a 50 per cent increased load over undulating roads. In regard to plowing, the motor will haul a four-furrow plow working from 7 inches to 8 inches deep with an actual kerosene consumption of 2.75 gallons per acre, which is equivalent to about 75 cents per acre, including all costs such as wages, wear and tear, lubricating oil, etc., while 6½ acres can be plowed in ten working hours, this being based upon the results achieved with hard, stiff clay loam in stubble, the motor working upon its lowest speed. It has been found from actual experience that a plowing speed of from 2 to 2½ miles per hour is the most satisfactory, since if the tractor be driven at a higher speed there is a danger of the plow jumping out of the furrow when it comes into contact with a stone. In regard to cultivating, this can be carried out at four miles per hour upon the second speed, from 12 to 20 acres being dealt with per working day of ten hours, according to the nature of the land. The advantages of this machine as compared with the ordinary methods of mechanical plowing were recently demonstrated. Heavy rains had been falling for several hours, so soddening the soil that the steam plow could not be used. Yet the work was successfully accomplished without any delay by means of this tractor, two four-furrow plows being used. From this it will be seen that varying weather conditions do not affect the operation of the machine, which is a point of great importance in climes where torrential downpours are of frequent occurrence. So far as concerns stationary working, the motor will drive a large-size finishing threshing machine with 22-inch diameter drum with a fuel consumption of 1.75 gallons of kerosene per hour, representing about 21 cents for fuel, while it has threshed with a full-sized machine for six hours with a fuel consumption of 9½ gallons of kerosene and about ½ gallon of gasoline, and has also

HAULING A LOAD OF 15 TONS OF GRAIN ALONG A HIGHROAD ON SECOND SPEED AT FOUR MILES AN HOUR.

A NEW AGRICULTURAL OIL MOTOR.

driven a 4-foot 6-inch threshing machine with a four-knife chaff cutter and chaff blower combined with equal economy. The advantage of such a machine as this is that the minimum of attention is required. One man can attend to the tractor, while the plow or cultivator requires the services of only another man, and under these conditions six acres of land can be plowed in ten hours. Should the tractor become stalled upon heavy ground, it can extricate itself either by means of the spuds or the wire rope and hauling tackle with which it is equipped, 150 feet of cable being carried on the machine expressly for this purpose.

The designers, however, have paid especial attention to the evolution of a machine that is capable of working continuously if necessary for twenty-four hours or more without stopping, and its possibilities in this direction were strikingly emphasized in a 24-hour non-stop trial that was recently carried out at Grayingham in Lincolnshire. The tractor was set to work at 10:30 A. M. on Friday morning, November 29 last, and was engaged incessantly with a six-furrow plow without a single stop until 10:30 A. M. the following day. During the twenty-four hours 22 acres of land were plowed with a fuel consumption of 44 gallons of kerosene, representing a cost for fuel of $5.50. During this run it was not found necessary to supply any additional water, showing the efficiency of the cooling system. The operations and capabilities of this tractor combined with its economical running have aroused considerable interest among agriculturists, especially in view of the fact that it is available at all seasons of the year for any farming purpose irrespective of meteorological conditions.

THE GAS-ENGINE CYCLE.*

A CONSIDERATION OF THE TWO AND THE FOUR CYCLE MOTOR.

BY W. H. BOOTH.

IN the two-stroke-cycle engine there must necessarily be cooling of the rods and glands, but it will help to a general comprehension of the subject if one remembers that, as is also the parallel case with superheated steam, the rods enter the stuffing-boxes from the exhaust temperature and leave the stuffing-boxes when moving into the high temperature of either superheated or burning gas; and, further, that the part of the rod which is most exposed to high-temperature steam or burning gas is that which last enters the stuffing-box and then only at the slow speed due to the position at that time of the crank near the dead center.

But there is a mechanical reason in favor of the two-stroke-cycle engine on which emphasis might be laid, if necessary, to strengthen an already very good case. In the four-stroke-cycle engine the stress in the piston-rod is reversed in direction just as it is in the double-acting engine, but in the double-acting engine useful work is being done; whereas in the single-acting four-stroke-cycle engine the piston is pushed back by the rod solely for the purpose of exhausting a few ounces of burned gases, and it is rapidly reversed in direction and dragged out again by the crank-pin, solely in order that it may pull in a few ounces of fresh air and gas. This is employing a ponderous and very costly mechanism in order to perform a duty that can better be performed by light machinery. The single-acting engine is made double size and this size is again doubled for the sake of the four-stroke-cycle principle.

The four-stroke-cycle principle is all very well in relation to little engines such as all engines were when the four-stroke-cycle engine first was made a practical affair. Some people seem to think that four-stroke working constitutes a "principle." It is a *modus operandi* only. Compression of the working stroke is a matter of principles, but the arrangement of the supply of gas and air is a mere matter of design, yet it is of very great importance, for it involves commercial questions and costs of serious value.

In England, where the Diesel engine has come into considerable use, the supply of the working charge to the cylinders of several engines has to some extent been made a matter common to several engines, so far at least as they all pump the air, for spraying the fuel, into a common system, and from this it is but a step to a general central supply of air and of gas from a central reservoir or reservoirs supplied by pumps specially devised for this class of work, namely, the supply of large volumes at low pressures.

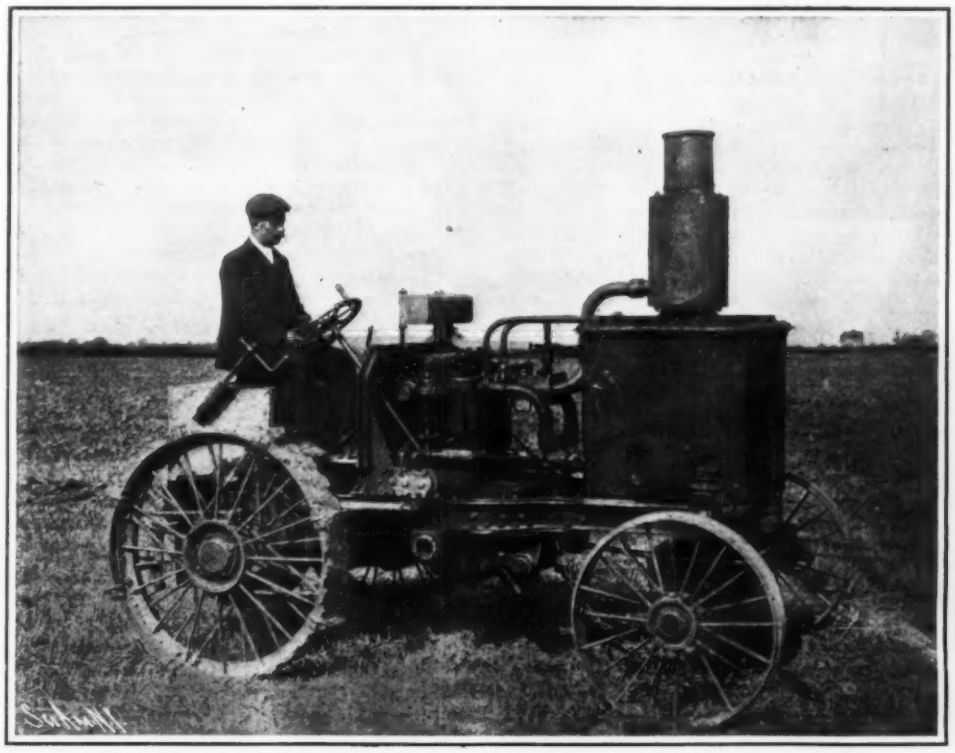
In many installations of blast-furnace gas engines, the scavenging of the working cylinder is done by air from the blowing tubs and what is needed in a large gas-power installation is something in the nature of a large and light blowing tub or bellows or a positive blower. In any case both the air and the gas supplies may be worked by electrical means where convenient to do this. There are, of course, very cogent arguments advanced against the two-stroke-cycle engine.

ARGUMENTS AGAINST THE TWO-STROKE ENGINE.

There is a double number of explosions in the cylinder end in a given time, and this may render the cylinder so much hotter that it cannot be kept sufficiently cool to work with the desired ratio of compression. The creation of this double quantity of heat in the same cylinder capacity necessarily diminishes, also, the cooling opportunities of the cylinder, and it may be true that at present a four-stroke-cycle engine is the leading engine, or is so claimed to be. But this is not necessarily a matter of principle. It may, if true, be due to a very good design, for it is not always that the machine on the best principles is always best designed, and an inferior principle may appear best in work, because the best has been done to make it a practical success.

But it is obvious that the heavy gas engine is a wasteful piece of machinery as ordinarily built, for it is a machine capable of taking pressures measured in hundreds of pounds per square inch and yet its mechanical efficiency is seriously reduced by giving half the engine nothing to do, though in the single-acting engine the front end of the cylinder has been used to supply scavenging air. Then the back end is made to do light work, so light that it could be done by a fan or bellows, and thus one-half the capacity of this end of the engine is thrown away as regards power production.

* In Power.



THE KEROSENE TRACTOR, SHOWING THE TWO-CYLINDER MOTOR, COOLING-TOWER TYPE OF RADIATOR IN FRONT, AND WATER-SUPPLY TANK AT THE REAR.

'A NEW AGRICULTURAL OIL MOTOR.

Every motive-power engine has a certain mechanical efficiency. The best steam engines are believed to have a mechanical efficiency of 94 per cent; they throw away 6 per cent in internal work and friction. The single-acting gas engine, which has only one working stroke in four, ought to throw away about four times 6 per cent, retaining a mechanical efficiency of 76 per cent, and this is probably very nearly the truth. A higher efficiency is claimed for some of them, but this may perhaps be very properly allowed, and indeed may be expected, as any property due to the higher mean pressure would naturally tend to greater mechanical efficiency, because for a given power the cylinder dimensions would be less, or the volume swept by the piston would be smaller. So great is the mechanical loss that it could not possibly be continued without attracting endeavors to remedy it by the development of double-acting and independent pumps for the movement of gas and air at low pressures.

As to the necessity for stratification, or the interposition of a layer of air between the charge and the exhaust port, those who uphold the four-stroke-cycle practice urge that gas is very apt to escape at the exhaust ports. Those who argue this way are men of ability and of experience and therefore entitled to be heard. We must believe that they have experienced the troubles that induce them to stick to the four-stroke-cycle engine, though we are perhaps entitled to think that it is simplicity they are really bent upon, no bad thing in its way but something that may be too dearly bought, especially if simplicity can be had with the two-stroke cycle also. Indeed, may it not be urged that, with independent air and gas pumps arranged to serve a whole battery of engines, the simplicity is really greater than with the four-stroke-cycle engine.

WORST MECHANICAL DEFECT OF THE FOUR-STROKE ENGINE.

Perhaps, however, the worst mechanical defect of the four-stroke-cycle engine is the continuous variation in the duty of its mechanism. In steam engines do we not always see to it that the initial pressure in the cylinder shall be more than sufficient to accelerate the piston and other moving parts, so that there shall be no tension on these during an out stroke and no knock as the result of catching up slackness? In the gas engine this knock is not often heard, but there is always the necessity of caring for it, the necessity of keeping all bearings closer, perhaps, than is desirable, that is, desirable for minimizing the risk of hot bearings due to lubrication difficulties. Do not gas-engine builders themselves recognize this fault or danger by placing two cylinders in line, so as always to have an explosive stroke to give the acceleration forces?

To revert to the question of gas escape by the exhaust ports; this brings up for consideration the means that may be adopted for preventing it. One of them is to employ longer cylinders, so that there may be a better opportunity to keep back the gas. If escape so regularly occurs, it must be due to the very serious turmoil in the cylinder. No doubt the entry of air is far from quiet and a cylinder is full of eddy currents and vortices which catch up the gas and sweep it through the cylinder. An endeavor has to be made to check these violent disturbances. For the fact of the universality of the short cylinder there may be some good reason. Just as we find that the steam en-

gine has fallen short of success unless it has been of a certain standard general construction; as the rotary engine has failed to achieve commercial longevity, from certain inherent defects in its mechanical constitution, so the gas engine may require to have a short stroke. On the other hand, it is not yet fully developed, and it may be that its best mechanical and physical development will yet find it of longer cylinder proportions and that it will get over the leakage difficulty. But at the moment the leakage of gas appears most certainly to be safe-guarded by commencing its inlet only after the exhaust port has closed. This, of course, demands that the gas shall have a pressure somewhat higher than otherwise necessary, in order that it may enter the cylinder against the slowly increasing pressure due to the progress of the compression.

Such are the points that still await solution in the problem of the gas engine and bear particularly on the vexed question of the relative merits of the two- and four-stroke cycles. It seems historically probable that the four-stroke-cycle engine is the parallel of the early steam engine which gradually assumed the present universal two-stroke double-acting form. This latter is a form easily possible because the working fluid enters from a storehouse of the fluid in the boiler. Similarly the gas engine requires to be fed with its working fluid from a pressure or storage system. For large stationary plants, capacious gas and air holders filled by a continually running pumping plant would appear to be in some cases desirable.

RECENT RADIUM INVESTIGATIONS.*

THE TRANSMUTING EFFECT OF RADIUM EMANATION.

BY SIR WILLIAM RAMSAY, K.C.B.

A RAY may consist either of shot-out particles; or it may be a bundle of ethereal vibrations; both are propagated in straight lines. To radiate is to send out rays; and a radio-active substance is one which is active in sending out rays.

We do not, however, speak of a candle as being radio-active; nor a tea-kettle. The word has come to mean capable of emitting rays which will effect the discharge of an electroscope at a distance. It has, of course, long been known that a pair of strips of gold-leaf, suspended from an insulated support, would diverge if touched with a rubbed piece of glass or of sealing-wax; the former charges them "positively," the latter "negatively." Up till recently, however, the expressions "positive" and "negative" were merely names to signify certain states; they conveyed no definite meaning. But recently, thanks to the researches of Prof. J. J. Thomson and his pupils, we know that a "negatively" charged body is one to which certain small particles termed "electrons" have been added; and contrary to the direct signification of the name, a "positively" charged body is one from which electrons have been removed.

There is no need for the salt of radium to be near the electroscope. Provided there is a tube connecting the vessel containing the electroscope with that containing the radium, the electroscope cannot be charged, or if an attempt is made to charge it, its leaves always fall. But by closing a stop-cock on this tube, after a time there is no difficulty in charging the electroscope. Something is evolved from the radium which can pass along a tube. It was not long before it was recognized by Dorn that this substance must be a gas; for only a gas can transfer itself in such a manner from one vessel to another along a connecting tube.

Somewhat similar properties were found to belong to salts of the much commoner metal thorium; it, too, appeared to emit continuously a gas, capable of discharging an electroscope.

The properties of these gases were first studied by Prof. Rutherford and Mr. Soddy, working at that time in Montreal. They found that the gases from thorium and from radium could be condensed if they were cooled to a low temperature by means of liquid air; they also discovered that no chemical agent, even of the most active nature, such as red-hot magnesium, or oxygen at the high temperature of the electric discharge, is able to alter the gas or to destroy its radio-active power.

Seal a little glass bulb, containing radium salt dissolved in water, to the intake tube of a mercury pump, which allows the extraction of the gas from the bulb and its collection. The radium, it will be found, decomposes water into hydrogen and oxygen, its constituents; and, although the volume of the emanation, the special gas produced by the radium, is so small that it could not be collected alone, there is no difficulty in extracting the gases into which it is mixed and with them the emanation itself. Moreover, there is no difficulty in separating these gases, because, as is well known, they are explosive; and when a spark is passed they combine to form water, leaving the emanation unaffected.

Introduce the mixed gases into a tube, little by little. In a dark room, they become visible, owing to the luminosity of the products into which the emanation changes. They will explode. The residue is very much brighter, owing to its greater concentration. On opening a stopcock, which connects the little explosion vessel with a long spirally wound glass tube, their passage along the tube can be seen. A plug of wool in the tube delays their passage somewhat, showing that it suffers friction in passing through the wool. At the end of the spiral is a large glass vessel containing some willemite—a variety of silicate of zinc—which is particularly sensitive to the rays evolved by the disintegration products of the emanation; and when the emanation reaches it, it will glow, and in course of time, the luminosity will increase, owing to the progressive change of the emanation. Its more active products are very short-lived; their motto is "a short life and a merry one," like ephemeræ; and in the course of a few hours they are disappearing as such at the same rate as that at which they are being formed; hence the brilliancy of the willemite will increase for a few hours, and will then remain constant for a long time, because these products are present, after a few hours, in their maximum amount.

Cool a glass vessel in direct connection with that containing the willemite, by means of liquid air. The emanation will be condensed, and in all probability frozen. It is thus almost wholly withdrawn from the bulb containing the willemite. On shutting a tap between these two bulbs, the emanation remains in its prison, and can be removed. This bulb then glows brightly.

These experiments may give some idea how it is possible to manipulate this curious gas, transfer it from place to place, and examine its properties. It can be transferred in a pure state to a "vacuum-tube," and its spectrum can be examined. A stencil of the spectrum of radium, its father, shows several red lines, and in its general character resembles that of strontium, one of the series of metals to which radium belongs.

A tube, called a Plücker's tube, containing the emanation from radium, also gives a spectrum.

On keeping such a spectrum tube for a week, a new spectrum begins to appear. It is that of helium, one of the argon series of gases. Helium can be extracted from a mineral named clevite, which emits a brilliant yellow light when stimulated by a current of high-tension electricity. Its spectrum, exhibited as a stencil, shows a bright yellow line, named D_3, together with many others. Both emanation and helium pass for elements, i. e., substances of a simple nature, which cannot be regarded as compounds in the ordinary sense of the word like water, or like common salt. How can an element remain an element if it changes into another? The answer is: There are degrees in the elementary scale as there are degrees in the stability of compounds. For example, rock-crystal is generally regarded as a very stable compound, because it is not decomposed by almost any high temperature. Yet it is perfectly well known that it consists of silicon and oxygen; or perhaps one should be more cautious and say one knows that when silicon and oxygen are heated together, silica or rock-crystal is formed; and from silica, silicon and oxygen can be obtained. Contrast its permanency with that of, say, nitro-glycerine, the chief constituent of dynamite, shattered by the least concussion. Different compounds, then, have different degrees of stability. And what we name elements are in all probability only enormously stable compounds. But not all compounds are stable; and not all elements, apparently. When a mixture of oxygen and hydrogen explodes, a compound is formed, namely water, and a relatively great amount of heat is evolved. In this case heat is lost, or given out, by the formation of a compound. But when nitro-glycerine explodes, it becomes less complex; it changes into simple compounds, water and carbon dioxide, and into the element nitrogen, all of which are its constituents. We name those compounds which are formed with evolution of heat, exothermic, or "heat out"; and those which are formed with absorption of heat, endothermic, or "heat in." Water is an exothermic, nitro-glycerine an endothermic, compound.

Now it is probable that elements, if they are really compounds, may admit of similar classification. The emanation, whether it be a compound or not, is certainly enormously endothermic; that is, if left alone, it changes and presumably decomposes, with an almost unrealizable evolution of heat. One gramme of radium emits each hour enough heat to raise a gramme of water through 100 degrees; and one gramme of emanation enough to melt a gramme of ice. As this form of statement may not be familiar to many present, let us put it in another form. Five and a half grains of radium would boil away a grain of water every hour; twelve pounds would evaporate a pound of water per hour. A ton would boil away 200 pounds of water each hour, and it would serve as efficient fuel to warm a house, do all the cooking and afford plenty of hot baths for a large family, not only during their own lives, but it would continue to perform these useful functions for about twenty generations without much falling off!

Yet it is not everlasting; it ceases to emit heat because it ceases to change. Theoretically, it will last for ever; but practically, it falls off in the course of a long time to a minute fraction of its original powers. As its theoretical life is infinite, we cannot ascribe a period to it, but we can to its "period of half-decay." An illustration will render this idea clear, though at first it may appear paradoxical. Suppose we take a bar of soap, cut off a twentieth part—an operation which we may suppose takes a minute—and during the next minute cut off a twentieth of what remains, i. e., nineteen-twentieths of the original; during the third minute, nineteen-twentieths of the nineteen-twentieths, and so on, diminishing what remains by one-twentieth each minute. It is clear that if the soap is infinitely divisible, we may go on cutting for ever, for it can always be mentally conceived that we can cut off a twentieth of what remains. But it is equally clear that there will come a time when only half the original bar of soap is left. This corresponds to the half-life period of radium. Without placing a numerical value on this, let me first consider the emanation. Its half-life period is pretty accurately known; it is very nearly 3¾ days. That is, every 3¾ days the emanation is half gone. Let us, for simplicity's sake, suppose the figure to be 4 days. Then in 4 days, half the emanation will have changed, and there will be a half left; in 4 days more there will be a quarter left; in still 4 days more, that is 12 days in all, one-eighth will be left; after 16 days, one-sixteenth; after 20 days one thirty-second; after 24 days one sixty-fourth; in 28 days, one hundred and twenty-eighth; so that we may say that after a month what is left is hardly worth counting; less than 1 per cent is left.

What becomes of it? You have an idea how it is possible to transfer it from one vessel to another; you can conceive that it may be forced up into a narrow tube, in which it can be measured; and that is what Mr. Soddy and I did, and more recently, Mr. Cameron. The last measurements, which I made with Mr. Cameron, are more accurate. Having measured it, we were astonished to find it rapidly contracting, and in about an hour and a half it had come down to half its original volume. Now, we do not know any gas which contracts slowly to half-volume in this manner; but we do know a gas, called nitric peroxide, of which the formula is N_2O_4, which, when heated doubles its volume, because a molecule of N_2O_4 splits up into two molecules of NO_2; and as equal numbers of molecules inhabit equal volumes, the NO_2 occupies twice the volume of the N_2O_4. And on cooling, the reverse takes place; two molecules of NO_2 associate themselves into one of N_2O_4, and the volume is halved. That is what happens to the emanation. When left alone, it halves its volume, and the presumption is that $2\,Em = Em_2$; two molecules coalesce to one, when heated to 80 deg. C.; it nearly doubles its volume again, and it must be concluded that one molecule becomes two; $Em_2 = 2\,Em$. All this time, however, it is changing its volume owing to another circumstance; it is slowly converting itself into helium—and something else. The "something else" has been called by Rutherford radium A, and that changes quickly into radium B; B is followed by C, and so on down the letters of the alphabet to F or G. Each of these substances has its own rate of change, and it is thus, chiefly, that each is recognized, as it is certain that no one of them is a gas. We are

* Abstract of a paper read before the Society of Arts.

not concerned with them here; we will leave alone the children and grandchildren of the emanation and consider the parent only.

Radium emanation, then, is changing slowly into helium. That it does so was discovered by the writer in conjunction with Mr. Frederick Soddy in 1903. It has merely to be left alone in a tube by itself or mixed with gases such as oxygen, nitrogen, or hydrogen, and after some time it is replaced by about three and a half times its volume of helium. It is interesting to compare the spectra of these gases. They are wholly different, and each is easily recognizable.

The emanation, as already remarked, evolves heat; during its change, it parts with a relatively enormous quantity of energy. If dissolved in water, it produces another effect, also evolving a loss of energy; it decomposes the water into oxygen and hydrogen. It is possible to do this by a very high temperature; when steam is heated to whiteness, it is decomposed thus. It is also possible to effect the decomposition of water by an electric current; but as pure water hardly conducts electricity, some salt must be added to the water. With emanation, however, pure water, the purest attainable, is thus decomposed. There is always a small excess of hydrogen, over that required to combine with the oxygen; and one hypothesis to account for this excess is that hydrogen, too, may be one of the products of the decay of the emanation. But, on the whole, that is unlikely. There is formed at the same time a trace of dioxide of hydrogen, a liquid richer in oxygen than water, and that may account for the small excess of hydrogen, although, so far as I can judge, not wholly.

It was while carrying out experiments on this curious decomposition of water that in conjunction with Mr. Alex. Cameron, who was assisting me, I discovered that the gases then obtained contain a mere trace of helium, and that on removing the oxygen and hydrogen, there is left neon, another of the inactive atmospheric gases which Dr. Travers and I discovered in 1898.

With the hope of accounting for the excess of hydrogen, I exposed a solution of sulphate of copper to the action of the emanation; and the gases evolved contained argon, but no recognizable helium or neon. And some of the copper, too, appeared to have changed; for the residue of the liquid, after removing all copper from it, contained a small trace of the element lithium, a member of the sodium group. Lithium, too, is easily recognized by its spectrum; it gives a brilliant crimson color to a flame, and its spectrum contains a brilliant red line, of which the position is well defined and not mistakable for the spectrum of any other element. It is probable, though not yet proved, that the element sodium is also a transmutation-product of copper; because the residue, obtained by evaporating the copper-solution, deprived of copper, which had been treated with emanation, was more than twice as heavy as that obtained from untreated copper sulphate. It must be explained that these solutions were contained in glass bulbs, and that glass contains silicate of sodium. Experiments are now in progress in which glass is excluded, for the bulb used is one constructed of silica, free from sodium.

Now these results corroborate each other, in a certain fashion, and admit of a provisional theory. The emanation, as already stated, is a very inactive gas, unattacked by any reagents. This is the characteristic of the argon group alone, namely, helium, neon, argon, krypton, and xenon. Again, we know a similar series, though a longer one, the first member of which is lithium, and the second sodium, to which copper, silver, and gold also belong. It appears possible, to say the least, that the emanation degrades, splits, is transformed, or transmutes itself into helium, neon, or argon, all members of the same natural group, according to circumstances; and that similarly, copper under the enormous influx of energy brought to bear on its atoms, may turn into lithium, sodium, and potassium, all of which have smaller atomic weights than copper, and all of which are usually classified in the same group. Some confirmatory evidence has already been obtained, which would appear to indicate that thorium, which also emits an emanation, is degraded by its energy into carbon, which appears as carbon dioxide in the experiments which I have made. All the results, however, not only need confirmation, but also extension, before any satisfactory theory can be propounded as to the relationship which undoubtedly exists between the properties of the atomic weights of the bodies which we have been accustomed to term elements.

SILVERING GLASS.*

HOW THE SOLUTIONS ARE PREPARED AND APPLIED.

BY E. C. C. BALY.

THE following recipes may be given for making solutions for silvering glass. The first one may be recommended in cases where a dense deposit is required for mirrors, and the second and third for purposes of half-silvering.

The first process is the one used by Brashear, and the directions have been given for its use by Wadsworth. The great advantage in its use lies in tne firm silver coating produced, which may be rubbed when wet with the hand or with a pad of cotton-wool without injury.

The reducing solution is made as follows:

Loaf sugar or rock candy	90 grammes
Strong nitric acid	4 cubic centimeters
Alcohol	175 cubic centimeters
Distilled water	1,000 cubic centimeters

The sugar is dissolved in the water, and then the alcohol and nitric acid are added. This solution should be prepared at least a week before it is wanted; the longer it is kept the better it gets.

The silver solution is an ammoniacal solution of silver oxide, to which, just before using, is added a solution of potassium hydroxide containing a weight of this compound equal to half the weight of the silver nitrate used. The silver solution must be made as it is required.

Amount of substances required calculated for round mirrors:

Diameter of Mirror, Cms.	Area, Sq. Cms.	Silver Nitrate, Grms.	Potassium Hydroxide, Grms.	Ammonia, (Sp. g. 0.880), C.c.	Reducing Solution.
30	707.0	15.0	7.5	12.0	85
25	491.0	11.0	5.5	9.0	65
20	314.0	7.0	3.5	6.0	40
15	177.0	4.0	2.0	3.0	25
10	78.5	1.8	0.9	1.5	10
5	19.6	0.5	0.25	0.5	3

The silver solution is made as follows: The silver nitrate and the potassium hydroxide required are dissolved separately to make 1 per cent solutions. To about nine-tenths of the silver solution the ammonia solution is added until the precipitate which first appears is just redissolved, and then some more silver solution until the precipitate reappears. The potash solution is then added, which will probably produce more of the precipitate; ammonia is then again added until the precipitate is dissolved, and then more silver solution, this being done alternately until all the silver nitrate has been added, taking care that the last addition is one of silver. In this way a solution is obtained which looks opalescent from the presence of a slight excess of silver oxide; this opalescence is absolutely necessary. If there are any floating particles, the solution is filtered; the necessary amount of reducing solution is added, the whole is mixed thoroughly, and then the mirror is immediately immersed. The mirror may be put with its face up or down, but best with its face up, as the depositing of the silver can then be watched; in this case it is necessary to keep the solution in constant motion in order to prevent any precipitated silver particles from settling on to the face. The best temperature is 21 deg. C.

When the silvering is complete, the mirror is lifted out and placed in an inclined position under a stream of clean water, and the whole surface is rubbed vigorously with a pad of clean absorbent cotton-wool until the white film on the surface of the silver is removed and the whole deposit is bright and clear. No further polishing is required. This process is not so good for half-silvering purposes as the older processes, because the deposit given by it is not so uniform although more durable.

The following recipe is given by Edser and Stansfield and gives very good results for half-silvering: 1 gramme of silver nitrate is dissolved in 20 cubic centimeters distilled water, and strong ammonia (0.880 specific gravity) is added until the precipitate is just redissolved. A solution of 1.5 grammes potassium hydroxide in 40 cubic centimeters water and again ammonia until the precipitate redissolves; 80 cubic centimeters distilled water are next added, and then silver nitrate solution (any strength) until there is a faint permanent precipitate. Make up to 300 cubic centimeters.

For the reducing solution 1.8 grammes of milk sugar is dissolved with the aid of heat in 20 cubic centimeters distilled water. The two solutions are mixed just before silvering, and the mirror is put in with its face down. At 15 deg. ten minutes are usually required for half-silvering, and one hour for full silvering. A thick silver surface obtained with this process may be rubbed with cotton-wool in running water.

Martin's process, which was used by Fabry and Perot for half-silvering the mirrors in their interference apparatus is as follows: Four solutions are made up:

A.

Silver nitrate	40 grammes
Distilled water	1,000 cubic centimeters

B.

Ammonium nitrate	60 grammes
Distilled water	1,000 cubic centimeters

C.

Potassium hydroxide (pure by alcohol)	100 grammes
Distilled water	1,000 cubic centimeters

To make solution D, 100 grammes pure sugar candy are dissolved in 1,000 cubic centimeters distilled water, and then 23 grammes tartaric acid are added, after which the solution is boiled for ten minutes. When cool, 200 cubic centimeters alcohol are added, and then, lastly, distilled water to make it up to 2,000 cubic centimeters.

Equal parts of A and B are mixed together, and similarly equal parts of C and D. Both these mixtures are mixed in the silvering vessel, and the mirror is at once suspended face downward in the solution.

It is needless to point out the absolute necessity for perfectly clean surfaces for the silver to deposit upon; these may be obtained by rubbing them with a cotton-wool pad dipped in warm nitric acid and then thoroughly rinsing with water. A further treatment with alcohol, followed again by water, is also advisable.

* From Spectroscopy.

NATURAL GAS PRODUCTION IN 1906.

THE value of the natural gas product in 1906 was $46,873,932, an increase of $5,311,077 over the product of 1905. The chief factor in the increase was the active exploitation of West Virginia. Pennsylvania, which consumed gas to the value of over $21,000,000, and Ohio with consumption of $12,652,520, both borrowed heavily from West Virginia. This State, which is now in the second place as a gas producer, running Pennsylvania closely, produced in 1906, 119,400,392,000 cubic feet of natural gas. Of this total product less than one-half, or 58,455,009,000 cubic feet, was consumed in the State, and 60,945,383,000 cubic feet were piped to other States for consumption. The total value of natural gas produced in the State was $13,735,343, of which it only consumed $3,720,440, so that the value of 60,945,383,000 cubic feet of gas piped out of the State was $10,014,903. The total value of natural gas consumed in the State is greatly reduced on account of the numerous manufacturing establishments which use gas in large quantities and to which the gas is furnished at a low price.

The increasing transportation of natural gas from one territory to another has tended greatly to the steadying of the industry and to the development of enterprises dependent upon it. The transportation of gas being so much cheaper than that of coal has enabled the natural gas to compete with coal at comparatively greater distances.

For the first time successful effort has been made to collect the quantity of gas produced.

In 1906 the product amounted to 388,842,562,000 cubic feet measured at the atmospheric pressure, or 9,396,963.8 short tons. The average price of $5 per short ton for natural gas is interesting, considering that the corresponding average price of bituminous coal in 1906 was only $1.11 per short ton. The difference is fully made up by the superior fuel efficiency of natural gas, weight for weight, by the great economy of labor in its use and the cost of removing ashes. —Abstracted from a bulletin issued by the Department of the Interior.

TARGET PRACTICE AT AN OLD BATTLESHIP.

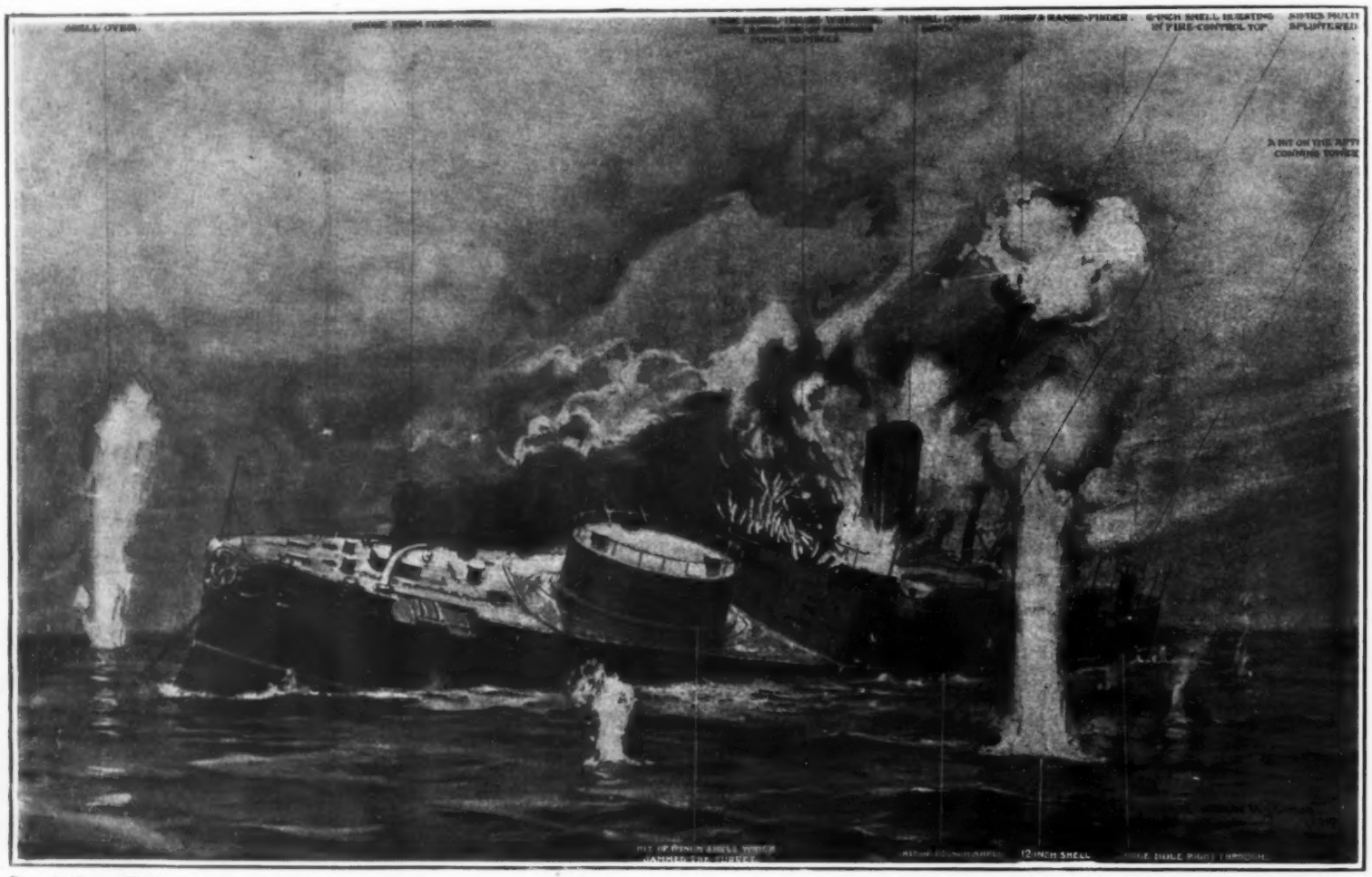
THE REMARKABLE GUNNERY EXPERIMENTS ON THE HULK OF THE "HERO."

IT will be remembered that, several years ago, the British government, in order to secure data as to the action of modern projectiles on the armor and hull of an armored ship, anchored the old battleship "Belle Isle" in a suitable position, and then had several battleships open fire on her with their large-caliber guns. It was claimed that valuable information, which otherwise could have been gathered only after an actual sea fight, was thus placed at the disposal of the Admiralty. The experience thus gained was incorporated in the later ships built for the British navy.

The experiment has lately been repeated with another old battleship, the "Hero." This vessel was built in 1888, in the days of compound armor, of which she carried 12 inches on her waterline, 11½ inches on the bulkhead, and 12 inches on the turret which contained her main armament of two 45-ton 12-inch guns. The belt, which extended to within about 40 feet of the stern, and tapered from a maximum of 12 inches down to a minimum of 8½ inches, was narrow, judged according to modern ideas, and reached only a foot or two above the normal waterline. Amidships, reaching from the belt to the level of the forecastle deck, was a central box battery, in which were mounted two 6-inch guns. Two other 6-inch guns were carried astern, one on each quarter. The turret is placed at the level of the forecastle deck, at the low elevation of not more than 9 or 10 feet above the sea. From about amidships to the stern the freeboard was raised by the height of one deck, giving a maximum freeboard in this portion of the vessel of about 16 or 17 feet. She had a single smokestack, in front of which, below the bridge, was a conning tower, and astern of the smokestack was the one mast carried by the ship.

In these experiments an effort was made to ascertain the action of modern gun fire upon the typical positions of a modern battleship. To this end, a dummy fire-control platform was rigged at the correct height on the mast. The hull of the ship was marked out in separate sections, all duly numbered, and in each of these was placed some of the various instruments and appliances peculiar to a modern battleship, and dummies to represent the men. The various sections of the ship were connected up by telegraphic and telephonic means of communication, such as will be used by a ship when under fire under modern battle conditions.

The "Hero" was attacked by some of the latest and most powerfully-armed ships of the British navy, using the latest pattern of long-caliber guns. Although the government made great efforts to preserve absolute secrecy as to the results, it is known that it took but a very short time to riddle the hull, silence the guns by complete disablement, and upset or destroy the dummies so fully, as to make it evident that under such conditions the crew would have been decimated. It is notable that a successful shot completely wrecked the fire-control station on the mast. So completely does the efficiency of the shooting now depend on the observations from the fire-control platform, that the carrying away of the latter, as in this case, would be about the most serious blow that could be struck at a ship. There are other positions, it is true, from which observations of the fall of the shots may be had and the firing directed; but being low down on the structure itself, they do not afford the accurate results the firing platform does.



Drawn by Norman Wilkinson from sketches supplied by an eye witness. From Illustrated London News.

THE EXTRAORDINARY GUNNERY EXPERIMENTS ON THE HULK OF THE OLD "HERO."

PROGRESS WITH BALL AND ROLLER BEARINGS.*

By S. S. EVELAND and HENRY HESS.

IT is probable that with the possible exception of the automobile industry, no business has developed so rapidly during the past five years as is the case with the ball and roller bearing business. In 1902, there were several small concerns making ball bearings, employing a total force not exceeding 100 men, women, and children; while at present, fully three thousand are employed, and the industry has grown so rapidly that over $5,000,000 capital is invested in the business.

The general and almost universal use of some form of anti-friction bearing makes it difficult to select applications of the principle having especial merit, although a few cases may be mentioned where their use has been notably successful. The field is too large to enter fully into detail, which can be more readily understood when it is considered that anti-friction bearings are sold for as little as one cent and as high as $6,000 for a single bearing, and they are in use carrying loads from a few ounces running at 35,000 revolutions per minute to mammoth loads in excess of 1,500,000 pounds.

The smallest bearing weighs one-fourth ounce, the largest 7,500 pounds.

Some evidence of the range in values in the steel ball business alone, is shown in the range of commercial sizes which are from 1/32 inch to 6 inches, inclusive. One ton of crucible, high-carbon steel, made into 6-inch balls, will sell for about $2,000, while of 1/32-inch balls, a ton would make a value of $24,000.

Great progress has been made in ball making, in many ways, during the past five years, during which time the accuracy of size and sphericity has improved from a possible limit of 0.002 inch plus or minus to a difference now in the best of balls of 0.0001 inch, plus or minus. An equal improvement has been secured in the strength and durability of balls, due to the use of special alloys of crucible, high-carbon steels. By the use of these special standard alloy steels, the crushing strength of balls of the highest grades has been raised over 100 per cent; a ball of a given size that would formerly have crushed at 25,000 pounds now requires 50,000 to 55,000 pounds to crush it. In consequence of this improvement in the strength of balls, they may now be applied and used where formerly it was not possible, owing to lack of sufficient space for the use of the proper size, for it is now practical to use a smaller size than formerly, to accomplish the result desired. Some evidence of the importance and size of the ball business is shown in the number of balls made in this country, which exceeds 600,000,000 per annum.

A new development in the use of steel balls is in roller skates, which used over 100,000,000 during the last year, and will probably exceed that amount this year.

In ball bearings of a special type, the greatest development is in the form known as the annular ball bearing, which consists of two concentric rings having grooves in the inner and outer face, in which the balls revolve and have a bearing surface of a considerable part of their radius. There is no adjustment, which was formerly a feature of all types of ordinary cup and cone form of bearing, but which is not necessary or desirable, in the improved type of annular

* Abstracted from the American Machinist.

ball bearing. This bearing is made of special alloy steel, and has been used successfully for many purposes where the old cup and cone, made of case-hardened machinery steel, failed in operation. Bearings of this character have been used successfully on motors and generators and have added 10 to 15 per cent to the efficiency of the electrical apparatus on which they were used.

In roller bearings, even a more rapid development has taken place than in ball bearings. Among the uses to which they have been applied during the past five years with exceptional success is on trolley-car journals.

The theoretical saving to be secured by the use of roller or ball bearings has long been fully understood, but the practical and actual benefits derived in practice are not so well known. Many tests have been made showing their value on machinery, but it is only recently that their use on trolley cars has proved not only successful but of practical value in many ways.

A trolley car has been run in Syracuse, N. Y., for over four and one-half years, fitted with roller bearings, which has shown remarkable results.

The roller bearings at the end of four and one-half years, and after running 250,000 miles, are in such condition that they may be relied upon to run many years longer. The rolls show an average reduction in diameter or wear of 0.005 to 0.008 inch, and it is evident that with the rollers, axle sleeve and car box or housings all properly hardened, as used in this construction, very little wear will take place.

One test made by the federal government some time ago of an army wagon fitted with and without roller bearing axles, demonstrated a saving ranging from about 52 per cent up hill to as high as 75 per cent on an asphalt drive, as shown in the table:

	Pounds Pull.
Asphalt test with common axle	100
Asphalt with roller bearing axle	25
Asphalt with common axle, starting load	450
Asphalt with roller bearing axle, starting load	220
Asphalt with 8 per cent grade common axle	400
Asphalt with 8 per cent grade roller bearing axle	170
Belgian block, common axle	165
Belgian block, roller bearing axle	75
Dirt road, common axle	260
Dirt road, roller bearing axle	100
Dirt starting, common axle	850
Dirt starting, roller bearing axle	400

It has been shown that an electric cab will run from 25 to 35 per cent farther on one charge with roller or ball bearings than when using plain bronze bearings. In using shafting hanger bearings a recent test showed that 18 heavy grinding machines, using 49 horsepower with the plain babbitted bearings, used only 27 horse-power when roller bearing shafting hangers were used.

One very considerable advantage that should be taken into account in the use of roller bearings, may be the adoption of motors of smaller size and consequent lower cost than are required at present. This results not only in the first cost saving, but in reduced weight of the complete car with a corresponding reduction in wear and tear of all parts, including the rails, etc.

Probably the largest anti-friction bearing of any form that has ever been made is a plain roller thrust, applied to a generator of 5,500 horse-power capacity, at Niagara Falls, where it has proved very successful after a commercial test exceeding two years and carrying a load of 200,000 pounds at 500 revolutions per minute, during which period it has developed no trouble of any character and has displaced the oil pump, brass pipes, and daily attention of various employees, all of which are required on ordinary oil pressure bearings.

A development of the past few years is in the use of the roller thrust propeller bearings on steam vessels. The same bearing that proved so successful on the Niagara Falls generator has been used with even greater returns in saving of power on many vessels.

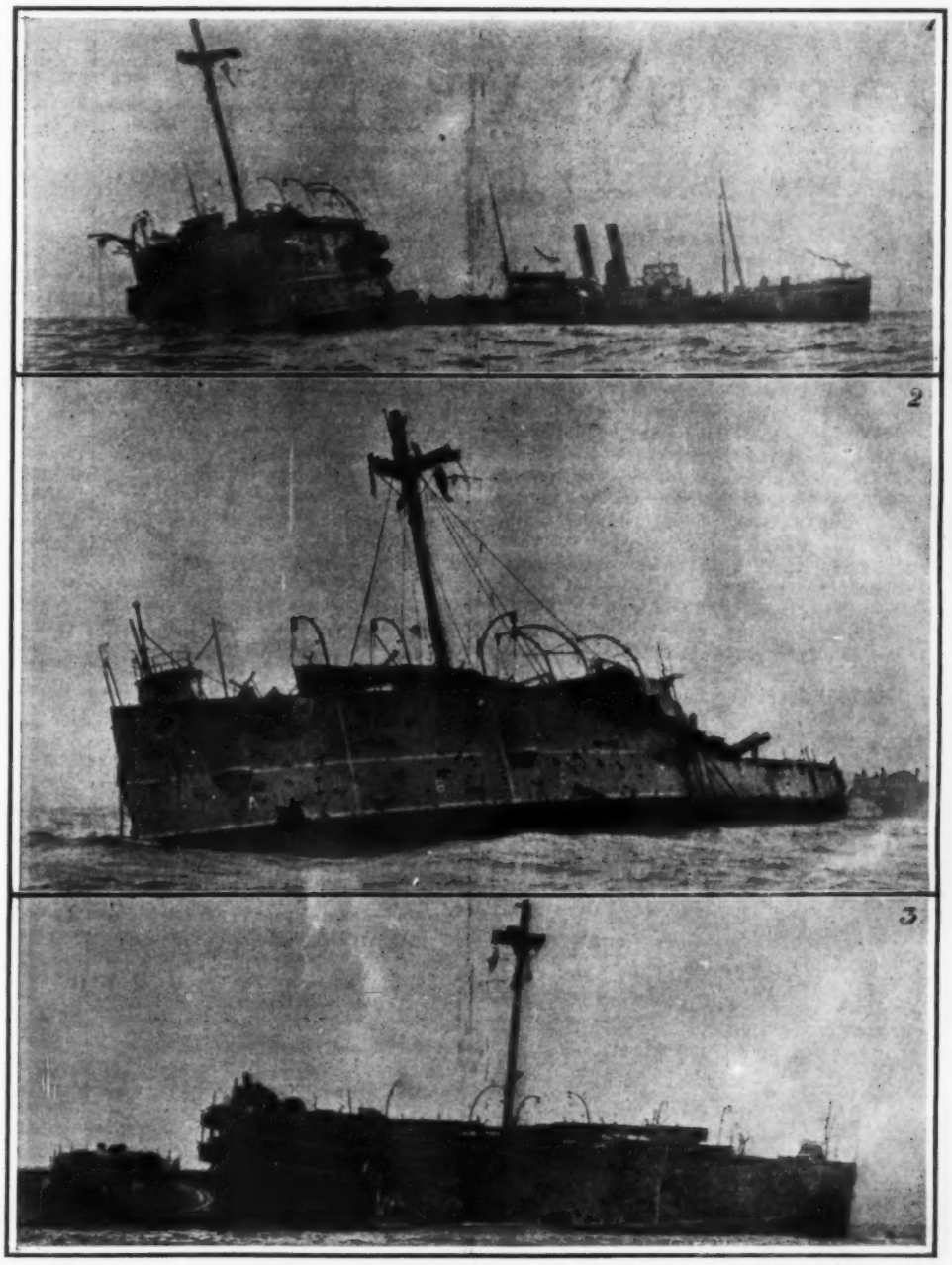
The roller thrust propeller bearing consists of two washers of tool steel, hardened and ground, and a set of rollers in a cage or retainer, which runs between the rollers, all being mounted in a horseshoe form of housing, which is recessed to receive them.

Several advantages are gained by the use of the roller thrust propeller bearing, the principal one being a material saving in fuel consumption, or an increase in speed, or a combination of both, while in addition, there is a considerable saving in oil consumption. No pump is required as with the old type, to force water through the bearing, and a very considerable reduction in vibration is secured. The exact cause of the latter fact is not fully understood, but it is quite possible that the old form of bearing "hugs" or sticks to the shaft collar, so that in actual practice it runs in the equivalent of a succession of jerks, due to the sticking and releasing referred to, in this way causing a certain amount of vibration. In the roller bearing, this cannot occur, as it is always running with a full rolling action, and there can be no such frequent releasing as may occur with the old form bearing.

The saving in power or increased speed, secured by the use of rollers, is so great that several vessels have shown an increase of speed of over one knot per hour, while in several cases the saving in coal has been from

From Illustrated London News.

THE "HIBERNIA'S" AFTER-TURRET DURING THE FIRING AT H.M.S. "HERO."



From Illustrated London News.

1. THE RIDDLED HULK OF THE "HERO" LISTING TO PORT AFTER THE FIRING; A TRINITY HOUSE STEAMER, WITH INSPECTING OFFICERS, IN ATTENDANCE. 2. WHERE THE SHOTS FELL THICKEST: THE HULL OF THE "HERO" RIDDLED TO A SIEVE. 3. THE WRECKED UPPER WORKS AND BARBETTE OF THE "HERO."

The old British battleship "Hero," which was prepared as a target for heavy guns, was fired at on November 30 by the "Dominion" and the "Hibernia." After five minutes' firing the "Hero" was listing heavily to port and settling by the stern, where she had been struck by a twelve-inch shell. There was hardly a whole piece of deck left. The firing began at a range of five miles. The accuracy of the practice was extraordinary.

THE EXTRAORDINARY GUNNERY EXPERIMENTS ON THE HULK OF THE OLD "HERO."

five to ten tons daily, according to the size of the vessel.

The earlier ball bearing was simply a series of balls introduced between a fixed and a rotating machine part; the outlines of the surfaces carrying the balls were generally due to the whim or fancy of the designer. Later came a recognition of the necessity for so arranging the ball tracks that theoretically pure rolling as dissociated from sliding was secured. Even to-day there are to be found many ball bearings violating this fundamental requirement.

Broadly, all ball bearings may be divided into classes characterized by the number of points of contact between the ball and the supporting surfaces or races. The simplest form provides only two contact points, then come three and finally four. So far as I know, no attempt has ever been made to provide more than four bearing points. By far the most generally used, up to a relatively recent date, was the three-point ball bearing that found employment in countless numbers in the bicycle trade. Only by gradual elimination has the present highest development of the two-point bearing been reached; as that is the acme of simplicity and, as made by the best specialists in the field, has carrying capacities and reliability of a very high order, it is safe to say that further development will not be in type but in details of manufacture and material. The defect of the older three and four-point type of correct outline was the great cost of so shaping the parts that the correct relationship of the contact points among one another and with the axis of rotation of the shaft was secured; with incorrect designs all benefit of the most painstaking workmanship was soon dissipated by the grinding action of the consequent partial sliding.

In the two-point type of that class in which the contacts lie in a plane at right angles to the shaft axis, close attention must be paid only to the correct sizing of the races by processes which are simple and not unduly costly. The correct relationship of the two contact points is even more readily secured by modern manufacturing methods. Next in order of importance came the development of suitable materials. In the early history cast iron was frequently employed and may even yet be found in an occasional turntable; needless to say it was only a slightly greater ease of working of rough machinery and not precision or great load capacity that was secured.

Next in order and probably practically simultaneously came the use of case-hardened iron or steel and of tool steel. The latter material found general favor where only a few ball bearings were made, but for a systematic manufacture it was found that tool steel was of too erratic a nature. Steel of carbon content so low as to be generally considered non-hardening could be far more readily controlled in quantities in the case-hardening furnace. While the final bearing did not have as great carrying capacity as its brother of tool steel, yet the immunity of troubles due to temper cracks, too great or too little hardness, etc., caused many to give this material preference. With the advent of the automobile a host of steels of the nickel and chrome series came into prominence and some of these are now finding employment in ball bearings with some resultant improvement.

So far no mention has been made of one of the most essential elements of the ball bearings—the ball. In the early days, balls were either primitively cast and primitively shaped, if shaped at all after coming from the mold, or were individually made from non-casting materials by laborious and painfully slow tooling processes. The next great step was taken almost at a single stride by the introduction of automatic machinery for truing the hardened balls by grinding processes in quantities at a time. Just as the material of the ball races has been subject to improvement, so has that of the ball. On the whole the difficulties of hardening have been less with the ball since the sphere is the ideal shape for hardening, owing to its uniformity of shape. It may be safely said to-day that of the two elements of a ball bearing, the ball and the race, the ball is in the lead.

It was the advent of the bicycle that really marked the commercial birth of the ball bearing. With the advent of the automobile the ball bearing again naturally came to the fore, since many of the bicycle builders graduated to this new field and carried the three-point and occasionally the four-point bearing with them. So long as machines were light and the owner of an automobile considered his possession of one a license to pay repair bills, these bearings did as well as the rest of the machine. Builders of heavier machines soon went back to plain journals and many to heavy expense in using hardened, ground, and lapped steel.

When the next step in advance in the shape of the two-point ball bearing of special steel was made the automobile builders avidly seized on it; occasionally a ball bearing of the older types is still met with on light automobiles, but the heavier machines have gradually extended the use of the two-point ball bearing to every element of the car, including even the crank-shaft and connecting-rod. The success of this type under such severe work as the modern road locomotive entails on it, gradually commanded the attention of engineers in other lines, until to-day ball bearings can be found in practically every line of mechanical engineering.

WORKING UP OLD PRINTED PAPER.

HOW USABLE PULP IS OBTAINED FROM WASTE PRINTED MATTER.

USED printed paper and paper cuttings have now an important place among the raw materials of paper manufacture. So much is this the case that large establishments exist for sorting purposes only, and many middlemen occupy themselves entirely with paper-scraps, printed or otherwise.

The chief points to be borne in mind in working up waste printed papers, is, that the new paper must be at least as good as the original paper; i. e., capable of being used as that paper was; that no special plant should be needed, and that the cost of the process should not be prohibitive. If these conditions are fulfilled there is no reason why the same cellulose should not be converted into paper many times over. There must, of course, be an end to this economical procedure, when the fibers are broken up so much that they cannot form a web.

The chief difficulty in the way of obtaining a usable pulp from printed papers is presented by the printing ink, and means have therefore to be sought of getting rid of this substance. The indelibility of printing ink is proverbial, but although it cannot be removed without disintegrating the paper, it can be removed after or during that disintegration.

Taking the chief sort of printed paper, viz., old newspapers, we find an inferior paper made of wood-pulp, cellulose, and fillings. The printing on it may be regarded as the result of the drying of a mixture of finely divided lampblack with an oily vehicle. On examining a printed letter under a high power, the black particles of lampblack and the gray dry residue of the vehicle can often be clearly differentiated.

The principle which underlies the removal of printing ink from paper is thus obviously to employ agents which will destroy or dissolve the vehicle which binds the lampblack, or other pigment (colored printing inks are now in extensive use), to the paper.

The first step is to tear up and disintegrate the waste paper in the ordinary manner. The resulting pulp is sieved, and it will be found that while the fiber remains on the sieve almost entirely, a fine sieve being of course used, a large part of the pigment which has been mechanically loosened from the fiber during the disintegration of the same passes through, together with much of the binding vehicle and nearly all the weighting and filling bodies present in the original paper. This, of course, much facilitates the subsequent treatment, as the pulp from the sieve is already partly freed from ink and other foreign bodies. One process to which it may be subjected is that of Knopf (German patent 127,820). This inventor treats the pulp from the sieve with soap-solution. It is then sieved again, and the soap carries most of the remaining pigment, which it has loosened from the fiber, through the sieve. The amount of soap required naturally varies within wide limits, i. e., from 3 to 22 per cent of the weight of the waste paper, according to the character of the paper, and the nature and amount of the printing ink present. The pulp on the sieve is rinsed free from the excess of soap with water. It is essential to work the process throughout without artificial heat, especially when dealing with cheap printing inks made from rosin oil. Heat would induce oxidation of the vehicle, and enable it to resist the solvent action of the soap.

Such a process entails loss of finely-divided fiber during sieving, and the conversion of the vehicle and filling into a lye or emulsion which will not only escape through the sieve but carry the pigment with it, is never complete, so that the best result is a pulp of a decidedly doubtful whiteness. The loss of fiber is often a very serious item, and sufficient of itself to make the process unremunerative. On the whole the best procedure is Knopf's, using two sieves, one below the other, and both as fine as possible. In this way, the nearest approach to a white pulp which can be got with a lamp-black ink is secured. The second sieve saves much waste of fiber.

In conclusion, it should be noted that these remarks are concerned with lampblack ink only. Many of the colored printing inks now in vogue are easily destroyed by bleaching agents without any injury to the paper fiber.—Paper Making.

GLASS TELEGRAPH POLES.

AN interesting industry has been founded in Germany for the manufacture from glass of poles for telegraph and telephone lines. For some time past there has been a dearth of wood in Germany for this purpose; and whereas the government formerly insisted that poles supplied for such purposes to their telegraph department should be perfectly straight and free from twists or notches, owing to the difficulty in fulfilling such requirements they recently relaxed the regulations, and now permit bent and knotty poles to be used within certain limits. The department experimented with iron poles, but they were found to be far from satisfactory, the cost of upkeep in regard to painting to preserve the metal from rust, and the high conductivity of the iron which became a serious factor during thunderstorms, combined with the initial high cost, seriously militating against their widespread adoption.

Recently, however, Mr. William Schutz, an architect of Cassel, evolved a reinforced glass pole in which the authorities have evinced a great interest. Glass was selected for the purpose, owing to its extraordinary durability and strength when built up according to his system. Combined with cheapness both in first cost and in maintenance, perfect resistance to climatic changes, fire, and acid, is its high insulation capacity, rendering it peculiarly adapted to electrical requirements, cleanliness, and possibility of decoration. By his system the poles can either consist of a glass rod strengthened with wire if desired, or reinforced at intervals with round hollow diagonals or cross-bars. The patents were duly taken up by a company, and now the factory is in full operation. The poles are produced by machinery, and as the result of further experiments, it has been found possible to extend the system to a variety of other purposes, comprising supports for carrying electric transmission wires and lamps, posts for fences, mine props, scaffolding, in short, to every application for which wood is at present utilized. At first the brittleness of the substance was considered to be somewhat against its adaptability to such commercial uses, but experiments have shown that when built in such a form as that contrived by Mr. Schutz, it can be subjected to considerable rough usage, though of course, as with cast iron and wooden poles, it can be willfully destroyed or damaged.

The manufacture of these poles moreover does not call for any particular skill upon the part of the glass workers; fairly intelligent labor is quite satisfactory, which is an important point, seeing that skilled glass workers are in great demand. The cost of producing a glass pole for carrying telegraph or telephone lines is only $2.50, while the market price ranges from $6 to $7 per post.

The imperial government is subjecting the poles made upon these lines to severe tests, several having been acquired and erected in various parts of the country. It is felt, however, that the greatest applicability of such poles lies in tropical countries, where the ravages of the white ant or teredo preclude the employment of wooden poles, and where, on the other hand, the cost of transporting cast-iron poles is prohibitive. It is stated that the government intends to adopt the poles experimentally for this purpose in their African colonies, the imperial engineers having been impressed with the great strength of the post.

The success of wireless apparatus of comparatively small power in operating over long distances in the Pacific is phenomenal. Recently the transport "Thomas" established communication with the naval station at San Francisco while she was 1,400 miles away. On the same voyage she intercepted a message from the naval station at Sitka, 2,200 miles distant in a straight line. This is the best performance recorded by the marine wireless. The new small portable wireless apparatus for field use with which the Army Signal Corps is experimenting has given excellent results, communication having been established for a distance of 26 miles overland.

KEEPER OF THE KING'S SEAL.*

WHO HE IS AND WHAT HE DOES.

LORD LOREBURN, who recently visited this country, is the first lord high chancellor of Great Britain to set foot on the shores of the western hemisphere, the first lord high chancellor, indeed, to leave his native land during his term of office since the days when Cardinal Wolsey accompanied Henry VIII. to the field of the cloth of gold in France. For the chancellor is the keeper of the great seal, and so great is the importance attached to this emblem of sovereignty, without which no legal value can be given to any acts of state, or to any documents bearing the sign manual of the sovereign, that all sorts of ancient laws, still unrepealed, provide for its custody by the lord high chancellor, who is responsible for its safety.

An old statute declares that it may not be taken out of the kingdom, and one of the offenses for which Cardinal Wolsey was impeached and punished was that he had violated the law by taking the great seal with him to France when he accompanied Henry VIII. to his memorable meeting with Francis I. And there are also pains and penalties devised for the chancellor who allows the great seal out of his keeping. So that, what between the difficulty of letting this instrument of power out of his personal care and the impossibility of taking it abroad, the lord high chancellor has always been prevented during his term of office from leaving the country. As lord high chancellor Lord Loreburn occupies the highest secular office of the British empire, and is its principal temporal dignitary, ranking immediately after the princes and princesses of the blood royal, and yielding the *pas* only to the primate of all England, the Archbishop of Canterbury. The chancellorship is not only the most illustrious but likewise one of the most ancient offices of the realm, the unbroken line of its holders dating back to 1068—that is to say, to two years after the Norman conquest. It carries with it a seat in the cabinet, a salary of $50,000 a year, an hereditary peerage, the prolocutorship of the house of lords, and a retiring pension of $30,000 a year for life, even if the position has only been occupied for a few days.

In addition to this the lord chancellor enjoys an enormous amount of patronage, having the appointment of all the judges, of high and low degree, from the lord chief justice down to the humblest justice of the peace and county magistrate, and the right of presentation to all the crown livings or ecclesiastical benefices. He is the supreme guardian, *ex officio*, of all infants, idiots, and lunatics, and as such, has the legal right to divest of the guardianship any persons who have been appointed as such by will, but who have shown themselves, in his opinion, to be unworthy of their trust. In that case he may either nominate other guardians or else decree the minor a ward of chancery, in which event any one endeavoring to wrong the ward or even to wed without the permission of the lord chancellor renders himself guilty of contempt of court.

Besides this, the lord high chancellor is, *ex officio*, a member of the privy council and president of all the courts of justice of the empire, which renders it indispensable that he should be a member of the legal profession. True, in olden times the woolsack was frequently occupied by ecclesiastics, but since the days of John Williams, bishop of Lincoln, who succeeded the great Sir Francis Bacon as lord high chancellor, the office has invariably been filled by a more or less distinguished lawyer, often of the humblest extraction, the woolsack being regarded as the highest prize of the legal profession.

There seems to be a general impression, even in England, that the lord high chancellorship must necessarily be held by a Protestant. But Mr. Gladstone made a careful investigation of the matter and ascertained that there was no law or clause of the constitution in existence to prevent the woolsack being occupied by a member of the Church of Rome, or a Jew. The title of "keeper of the King's conscience," which is one of the official designations of the chancellor, of course dates back to the days prior to the reformation, when the post, as mentioned, was ordinarily occupied by some prelate, who was usually the sovereign's spiritual adviser.

The woolsack, of which mention is so frequently made, is the seat occupied by the lord high chancellor as prolocutor of the house of lords. It is a sort of broad, square flat divan, blue cloth covered, supposed to be packed tightly with wool. Contrary to the general opinion, there are several of these woolsacks placed in the center of the house, midway between the throne and the cross benches. It is the one nearest the throne that is occupied by the lord high chancellor. The others are reserved for the use of the judges of the high court, who sit for the purpose of giving legal advice, but do not vote in the house of lords.

The woolsacks date from the reign of Queen Elizabeth, when stringent laws were enacted to prevent the exportation of wool, which was then regarded as the chief source of the wealth of the nation, and that the importance of this staple product to the realm might be kept constantly in mind by the legislators, woolsacks were placed in the house of peers, whereon the judges sat. It must thoroughly be understood that the lord chancellor is not the president or even the speaker of the house of lords. He cannot be said to preside over its deliberations, and has no such authority to guide its discussions as that enjoyed by the speaker in the house of commons. He has no authority to prevent any peer who is addressing the house from wandering away from the subject under discussion, nor to call him to order, not yet to reduce him to silence. He takes part in all the votes, and is at liberty to speak upon any question that comes up, not in his capacity as chancellor, but as one of the peers of his rank in the nobility. On such occasions he delivers his remarks not from the woolsack but from the bench of barons, or viscounts, or of earls, according to the grade of his peerage.

The lord chancellor is created neither by writ nor by patent, but by the mere delivery of the great seal into his custody by the King, who may likewise remove him from office by commanding his surrender of this instrument of sovereignty. It is used on all occasions when the will of the monarch is to be officially expressed. Its impress in wax is attached to every royal charter, warrant, or official document bearing the sign manual of the sovereign. It is used for all acts of state, for writs to summon parliament, for the ratification of foreign treaties; and all these documents have no legal value unless sealed with the great seal. That is why King James II. on his flight from England deliberately dropped the great seal into the Thames, knowing that there was nothing that he could possibly do that would cause so much inconvenience to the government which had disposed of him, as the absence of the great seal, and the impossibility therefore to summon parliament or to undertake any sovereign act until a new one was engraved. If he dropped it into the river rather than carry it away with him to France, it is because he believed that he was being closely pursued, and that he was almost certain of being captured before he reached the mouth of the river. The seal was recovered in the nets of a fisherman.

There have only been one or two occasions when the great seal was lost. Thus, Lord Chancellor Thurlow was robbed of the great seal through the burglary of his London residence and it was never heard of again, the party spirit being so strong in those days that Lord Loughborough, who formed part of the administration, actually ascribed the burglary and theft of the great seal to the opposition, as a maneuver destined to embarrass the government.

Royal purple bags of velvet, gold embroidered and adorned with the royal arms of Great Britain, hold the great seal in these days. The state furnishes a new bag of this kind every year at a cost of about $400, and the old bag becomes the perquisite of the wife of the lord high chancellor. On all state occasions the great seal is carried in its gorgeous bag by the lord high chancellor himself, who is arrayed in sweeping black silk robes, all covered with gold lace and embroidery, his hair, or the remnants thereof, being concealed by one of those full bottomed wigs such as were worn by King Charles II. of England and Louis XIV. of France. On minor occasions, the great seal is borne before the lord high chancellor by a stout and portly clerk, arrayed in black knee breeches, black silk stockings, and pumps, lace cuffs and cravat, and a coat of seventeenth century architecture.

* Abstracted from the Tribune Magazine.

DIPTYCHS.

THE need for communications in writing and for inscriptions of various kinds, was felt no less strongly in the days of antiquity than at the present time, and in Athens and in Rome the knowledge of reading and writing was by no means confined to the upper classes. Instruction in schools began with reading, writing, and reckoning. The A B C pupils made their first attempts with a stick in the sand; afterward they scratched their letters upon wax tablets. Thin sheets of lead, parchment, and paper made from the papyrus, were also used for writing, but wax was the most common material for many centuries, where short pieces of writing, letters, etc., were concerned. Square tablets, mostly made of thin wood, and having a rim upon one side, were coated over with a thin layer of wax.

A sharp metallic pencil was used for making the letters, and one end of it was broadened and flattened, for the purpose of making corrections by smoothing out the wax. Often two tablets of this kind were fastened together by hinges, so that they could be closed into one, making a kind of note book, called a diptychon. Diptychs were also used for letters; little, delicate tablets, which could easily be held in the closed hand, were in favor for love letters. In a Pompeiian painting, we see Cupid carrying a letter like this from Polyphemus to Galatea. If the letter were to be sent by a messenger, the tablets were tied together and sealed over the knot and the address written on the outer side.

Diptychs such as were in ordinary use have been preserved in considerable numbers. A great many were found in the old Roman fortifications at Vörös-patak and Abrundbanya in Hungary. In 1875 more than 300 diptychs, triptychs, and polyptychs were found in a chest in Pompeii.

The wealthy Roman did not content himself with simple wooden tablets, but had richly decorated diptychs made of costly materials. In the time of the later emperors it was the custom for the higher officials, the consols, prætors, and ædiles, to present to their intimate friends and to the senators, on the day of their accession to office, costly diptychs, called "diptycha consularia," "diptycha prætoria," etc. Ivory was considered the most elegant material, but according to edict of the emperors Valentinian II. and Theodosius I. only the consuls were privileged to give ivory diptychs. Not many of these have been preserved, and those which are extant in museums and ecclesiastical treasure chambers are not only the greatest of rarities, but possess very high artistic and ethnographic value. The most ancient consular diptych known to exist is that of Probus from the year 406.

Diptychs found very early use in the Christian church. Upon them were inscribed the names of martyrs, bishops, princes, and benefactors of the church, and other persons who were to be remembered in prayers. They were displayed upon the altars, at first only during worship, but afterward became permanent altar ornaments. They were made of precious materials, ornamented with figures of saints, and with biblical and legendary scenes. The barbarians who came under the influence of Rome, especially the Germanic tribes, adopted the diptych in its consecrated form. Old Christian diptychs were very rare, however, and they were soon imitated, at first unskillfully, then more freely and understandingly; and in such carved ivory tablets we may seek the first evidences of activity in plastic art among the Germanic nations. In the Carlovingian period, owing to the connection with Italy, late Roman works were the models. Not until the second half of the tenth century did the Byzantine influence make itself felt, through the importation of ivory work from Constantinople; this was increased during the time of the Crusades, by the capture and plundering of that city. The first German ivory work which has a definite date is that preserved at St. Gallen, done by Tutilo, who died in 911; but the large diptych representing a company of priests, preserved in the municipal library in Frankfurt a/M., is a greater work and older. The use of diptychs in public services ceased in the western church in the twelfth century, but the diptych did not disappear with this. It became the form for house and traveling altar, and as such was a prominent subject of ivory carving as late as the sixteenth century. Small folding altars are still to be found in the Greek Church.

Consular or early Christian diptychs are very rarely, if ever, to be found for sale at the present day; but folding altars of ivory, in this shape, dating from the thirteenth to the fifteenth century, appear quite frequently in auctions.—Adapted from the German.

When sulphur is burnt in oxygen at atmospheric pressure, about 2.76 per cent is converted into sulphur trioxide. When burnt in air, about two and a half times as much—say 7 per cent—of the sulphur forms trioxide. The humidity of the gas, and the presence in it of carbon dioxide, appear to have little influence on the proportion of sulphur trioxide formed, whether air or oxygen be used; but the proportion of nitrogen present does affect the yield of trioxide considerably, and it would seem that the nitrogen acts as a carrier of oxygen to the sulphur dioxide, doubtless through becoming oxidized itself in the first instance.

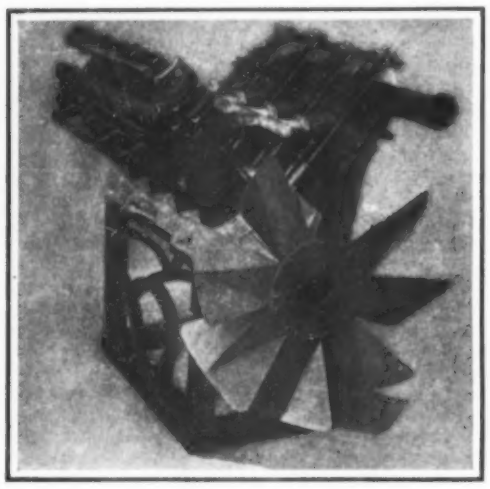
GASOLINE MOTORS FOR AERONAUTICAL WORK.

SOME OF THE MOST RECENT LIGHT WEIGHT MOTORS OF FRENCH DESIGN.

BY OUR PARIS CORRESPONDENT.

THE DUTHEIL & CHALMERS AIR-COOLED ENGINES.

SANTOS DUMONT has mounted on his most recent aeroplane a new double-opposed-cylinder motor of the air-cooled type which attracted considerable attention, as it is the first motor to appear of a new make which will no doubt be employed extensively for aeronautic



A 40-HORSE-POWER FARCOT AIR-COOLED MOTOR.

work in the future. Santos Dumont expresses himself as being very well satisfied with it as far as he has had occasion to try it, and he is especially pleased with the absence of vibration which is obtained by the balancing of the working parts. Upon a subsequent visit to the works of the makers, Dutheil & Chalmers, the writer had occasion to obtain some of the leading data about the new motors of this type and also concerning some newer forms which are soon to be built. Referring specially to the present motor, it contains two horizontal cylinders placed opposite each other and offset. The two connecting rods are fastened to the two cranks of the crankshaft, which is made of a very high grade of nickel steel. As the motor is of the regular double-opposed-cylinder type, the pistons approach or separate simultaneously and there is one explosion per revolution. The balance is excellent when the motor is running and there is a notable absence of shock or vibration.

The cylinders, which have a bore of 125 millimeters (4.921 inches), are of cast iron and have a thickness of 2.5 millimeters (0.088 inch). The cylinders are reinforced by sheet steel rings which are stamped out to suit the requirements and forced onto the cylinders. These rings answer a double purpose, being used for bracing the cylinder as well as for giving the needed cooling surface. A light weight is secured in this way for the cylinder and its cooling flanges, which weighs complete less than two kilogrammes (4.4 pounds). As for the cylinder heads, they are of cast steel. While very light, the connecting rods are provided with bearings of phosphor bronze, which is very hard and gives a large friction surface with good facility for taking up the wear. One point which has been well worked out is the oiling of the motor, and the disadvantages which are usually met with in the horizontal type of motor are now quite overcome by the methods used here. Oil tanks having a sufficient capacity for three hours consecutive running of the motor are made to communicate with all the parts where there is friction, such as the cylinders, wrist pins, crank pins, and crankshaft bearings. The output of these tanks is assured automatically by using the centrifugal force produced by the pieces of the motor in movement, and the regulation of the supply is carried out by the depression in the oil reservoirs which is produced by the movement apart of the pistons. In this way the constructors obtain a very regular and efficient lubrication of the motor. The pistons are oiled at the upper part, and the oil is carried all around the inside of each cylinder by means of a groove in the piston.

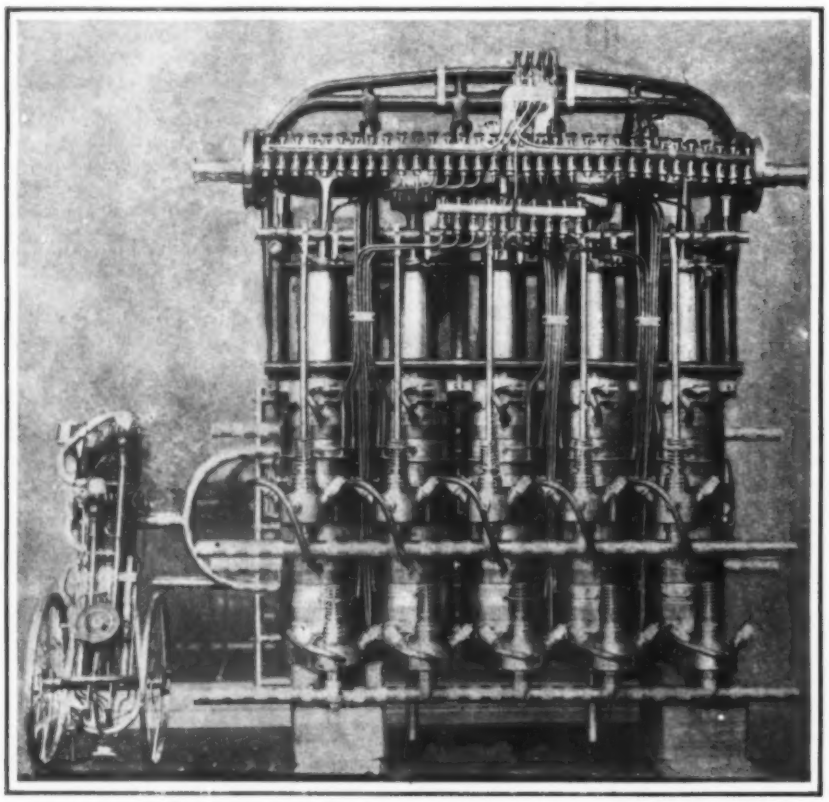
It is to be noticed that the motor does not carry any flywheel other than the propeller of the aeroplane and this is mounted directly upon the end of the crankshaft. The propeller sends a strong draft of air upon the cooling flanges of the cylinders, and this is found in practice to be quite enough to properly cool the motor. Attention should be drawn to the question of the weight of the motor, which is one of the most important points. Since the motor is air-cooled the radiator, pump, gears, and the weight of the water itself are all dispensed with. Thus the weight of a water-cooled motor, which may be given as having reached as low as two pounds per horse-power for the motor alone, must necessarily be increased by the weight of the above parts and also the water, and this will give a gross weight of nearly double, or four pounds per horse-power. For an air-cooled motor, provided the cooling is efficient, the weight which is given represents the gross weight, all included. In the present case, the total weight of the motor, which will give more than 20 horse-power, includes the carbureter,

FARCOT 10-HORSE-POWER MOTOR.

induction coil, and magneto (as double ignition is employed), and this weight is but 22 kilogrammes (48.5 pounds). This gives very nearly 2.4 pounds per horse-power.

The same constructors are now engaged in building two other motors for Santos Dumont, which are to be of much smaller size, however, as they give but 7 horse-power. As to the weight of these small motors, it is figured that it will not exceed 5 kilogrammes (11.2 pounds), which gives 1.6 pounds per horse-power. M. Dutheil informed the writer that Santos Dumont intends to build a new airship and that it will be the smallest which he has yet constructed. With it he is to sail at a short distance from the ground, as he wishes to show that amateurs can readily sail a light airship and that this will prove a sport much more interesting than automobiling. It appears also that there are a number of amateurs who intend to build small airships at Paris within the near future.

Besides the above, Messrs. Dutheil & Chalmers are to build a 25-horse-power motor which has been ordered by the balloon factory of the English government. This establishment is located at Farnborough, and is connected with the Aldershot aeronautic headquarters. Some special features will be embodied in the new motor which will make it somewhat different from the present type. It will be able to make a continuous run of twelve hours when under full load, and will weigh 2 kilogrammes (4.4 pounds) per horse-power, including the cooling apparatus, which is of a new type and will have some original features. This motor was ordered after the tests of the first motor by Santos Dumont had shown that this type of two-cylinder horizontal motor would work satisfactorily. The new motor will not be water cooled nor will it have cooling flanges, but the method which is adopted for cooling it cannot be made public at present.



THE 120-HORSE-POWER DUFAUX AERONAUTICAL MOTOR. TOTAL WEIGHT, 187 POUNDS.

The small motor at the left is of similar design but of the air-cooled type. It was used on a model helicopter.

THE DUFAUX NOVEL WATER-COOLED ENGINE.

The Dufaux firm, one of the well-known Swiss automobile houses whose works are located at Geneva, has recently brought out a light-weight motor for aeroplanes or airships which shows some remarkable features, and is different in many respects from what has been constructed up to the present. Our illustration gives a general idea of the new motor. Its weight is 85 kilogrammes (187.3 pounds) and when running at its normal speed it will give 120 horse-power, thus reaching the remarkably low weight of 1.56 pounds per horse-power. The speed of the motor is 1,500 revolutions per minute. It is made up of ten cylinders arranged side by side in five superposed pairs. Each pair of cylinders has a tubular crosshead and separate crank on the main crankshaft of the motor. As the engine is double-acting, the ten cylinders are equivalent to twenty. On account of their arrangement in tandem the constructors claim that in spite of a very light weight they are able to obtain but a low strain upon the metal of the working parts. As to the cooling

of the cylinders, it is carried out by means of a water circulation in the water jackets which surround both cylinders and heads and are made of separate pieces of sheet copper. The cooling effect is very efficient in this case, without making the water rise to an excessive temperature. The pistons as well as the different piston rods of the motor are made hollow and are given a very effective cooling by means of a current of air which is constantly forced through them. This is a new point which is worthy of notice, and it seems to be a decided advantage. By the use of a type of centrifugal pump designed for the purpose and also an air fan, the water and air circulation through the motor are well carried out. The oiling of the motor is quite thorough, and a very high speed of oil circulation in the different bearings is assured by the use of three special oil pumps. These pumps draw up the oil from a common tank placed beside the motor, and each pump injects the oil into a distribution tube on which is placed a sight-feed lubricator. Besides, each pump is provided with an arrangement for regulating the oil feed. From each of the sight-feed lubricators there is a small tube which passes to a certain part of the motor. One point to be noticed is that the oil tubes are disposed so that the parts of the motor to be lubricated are connected to pipes in which there is a pressure corresponding to the gas pressure upon these parts. This condition is essential in order to have a regular feed from the lubricators. Among other points about the Defaux motor we noted that the framework upon which the cylinders are mounted is made of brazed steel tubes and is very strong. All the pieces of the motor, such as the cranks, valve-rods, camshafts, and cams, are made hollow. The motor is provided with double ignition, and the distribution of the secondary current is made upon a fixed drum. The ignition shifting is obtained by an angular movement of the camshaft. It will be remembered that the Dufaux Brothers carried out some very interesting experiments with a helicopter not long ago. These experiments we described and illustrated at the time. Their apparatus was put through a series of tests at Paris. The helicopter consisted of a frame containing the small motor seen beside the large one in the picture on page 28, and two horizontal propellers, and it was able to lift itself in the air without any difficulty.

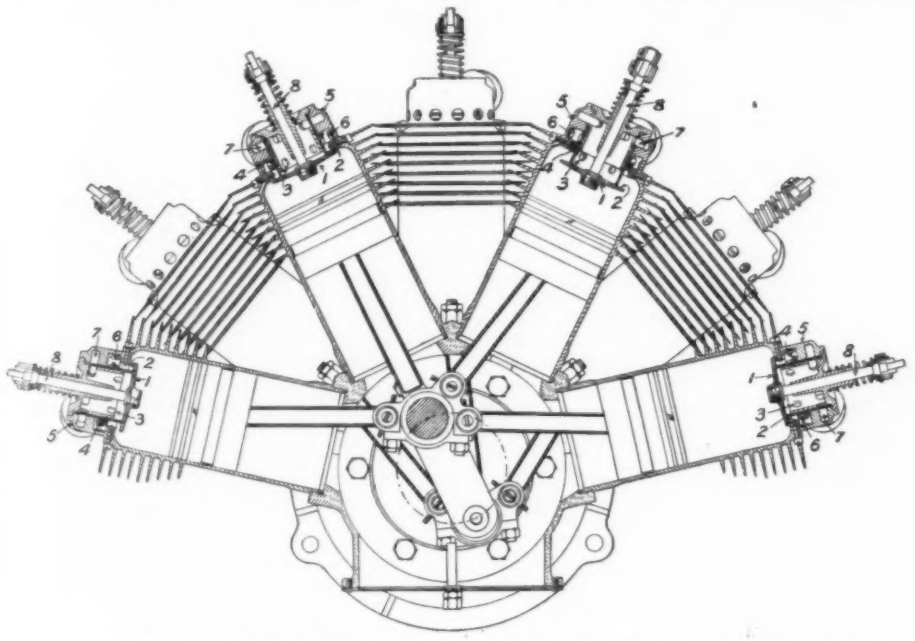
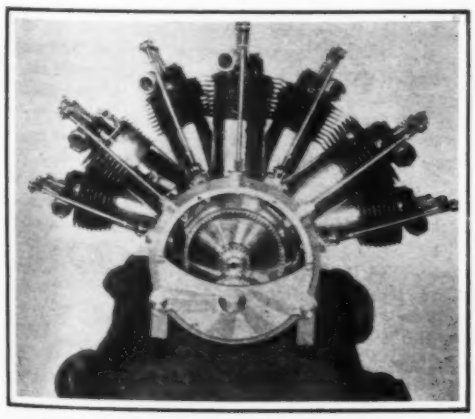


DIAGRAM OF R. E. P. 7-CYLINDER ENGINE, SHOWING FOUR CYLINDERS IN SECTION.



THE PELTERIE 7-CYLINDER MOTOR.

The crank case is cut away so as to show the cams.

THE R. E. P. AIR-COOLED MOTORS.

M. Esnault-Pelterie is one of the Paris aeronauts who has had considerable success of late. For his new aeroplane, he designed a motor which has some striking features, and finding it to be well adapted for this kind of work, he has now gone into the manufacture of such motors at his establishment near the city. What he desired was to secure solidity, a good distribution of the forces, and constant torque. For this latter purpose the explosions must come very near together and the impulses be transmitted to a single crankshaft. Such an idea can be realized by disposing the cylinders in star fashion around a central crank case. It is of the greatest interest to suppress the flywheel, but to do this, the explosions must be exactly distributed. Moreover, in two revolutions, all the cylinders should be fired, but in the second revolution the same set of cylinders must not be used as in the first. Thus it is necessary to have an uneven number of cylinders, which is the only means of satisfying the above conditions. In practice, all the cylinders should be above the horizontal plane passing through the axis of the motor, so that the oil will not run into the lower cylinders. To do this the second set of cylinders must be in a second vertical plane parallel to that of the first set, which secures the form of motor illustrated herewith.

According to the description which M. Esnault-Pelterie kindly furnished the writer, the crankshaft has two cranks placed at 180 degrees apart. The arrangement of the cylinders in fan shape allows of shortening up the length of the crank case, and thus the crank is shorter and much stronger. The crank has been designed according to the best formulæ, and weighs but 5½ pounds for 30 horse-power. Nowhere does it bear a strain of more than 15 kilos per square millimeter (21,334 lbs. per sq. in.) when running. The bearings are of very liberal dimensions, especially the propeller bearing. An interesting feature of the 7-cylinder motor is the arrangement of three connecting rods on one crank, and four on the other. As can be seen from the cross-sectional drawing, one connecting rod is integral with the crankpin box, which has suitable sockets for the pivot-pins of the other connecting rods. An endeavor has been made to reduce the weight of the ends of the rods, by lessening their volume without reducing their active surface.

As to the cylinders, owing to the special valve mentioned below, they are quite symmetrical about their axes and are fixed to the case by three bolts which are well locked. They are fitted with a combined inlet and exhaust valve of novel form, which is shown in different positions in the four sectioned cylinders in the drawing. Besides the main valve (which is carried on the valve stem, 8) there is a cylindrical piston valve combined with it and mounted on top. Within this cylindrical part of the valve is a sleeve extending down nearly to the plane of the valve seat, which is outside of the piston valve in the cylinder head. The sleeve has a series of inlet ports, 7, at its upper end, and these ports are closed by the piston valve when the valve is shut, as shown in the second sectioned cylinder from the left, which is cylinder 3 of the motor. The holes shown in dotted lines in cylinders 1, 3, and 7, and in full lines in cylinder 5, are in the cylindrical piston valve. When the valve is shut or only half way open, these holes are closed by the solid sleeve within it; but when the valve is opened to the full extent, as shown in cylinder 5, the holes, 3, are below the bottom of the sleeve, and the incoming gas can then pass through the ports, 7, and holes, 3, into the cylinder. There is also a second valve, which consists of a tapered ring, 4, on the exterior of the piston valve. When the main valve is only half open, as shown in cylinder number one, this valve is not seated, and consequently the exhaust gases are expelled past it and out of the holes, 6. When the main valve, 1, is completely open, the secondary or exhaust valve, 4, finds its seat (which is above that of valve, 1, in the cylinder head), and thus the exhaust passage is closed, as shown in cylinder, 5. The main valve is shown closed in cylinders 3 and 7. One of the special points of this device is that the seat of the valve is withdrawn from the action of the exhaust gases, so that there is no pitting. Moreover, the incoming gas cools it well, so that the valve never heats or warps.

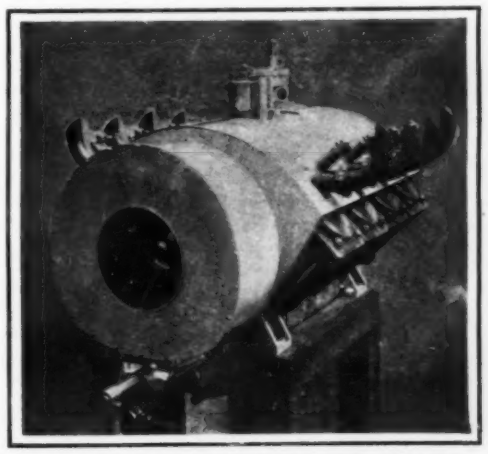
Although apparently the cam arrangement for operating the valves is very complicated, this arrangement is, on the whole, quite simple. In fact, all the seven valve push-rods are operated by a single disk having double-faced cams. This disk turns in the opposite direction to the crankshaft of the motor at one-sixth the speed. It contains three cams equally distributed on its periphery.

In any motor of this type, if N represents the number of cylinders, the cam disk should turn at $\frac{1}{N-1}$ the speed of the motor crankshaft and in the opposite direction, and it should have $\frac{N-1}{2}$ cams equally distributed on its periphery.

The crank case of aluminium is made in a single piece and has a large opening for inspecting the inside. As to the piping of the motor, it has some peculiarities on account of the arrangement of the cylinders and the order of the explosions. The piping is divided into two parts, using two separate carbureters. High tension ignition is employed, and the distributer is placed far enough away from the motor to avoid contact with the oil. The distributer is simply an ebonite disk which revolves at half the speed of the motor. On the disk is a metal contact which passes by the brushes. Each of the latter corresponds to one cylinder. The cylinders are cooled by ordinary cast radiating flanges. No fan is found necessary. The 30-horse-power motor weighs as follows: Crank, 2.5 kilos (5 pounds); pistons, 6 kilos (13.2 pounds); connecting rods, 10.5 kilos (23.1 pounds); crank-case weighs 5.25 kilos (11.55 pounds). The complete motor alone weighs 47.5 kilos (115½ pounds), or 52.5 when in running order. Adding the coil, batteries, and even the propeller, the total weight does not exceed 60 kilogrammes (132 pounds), making only 2 kilogrammes (4.4 pounds) per horse-power. The R. E. P. motor is designed for 20, 30, 40, and 60 horse-power, with 5, 7, 10, and 14 cylinders respectively.

THE FARCOT AIR-COOLED ENGINES.

M. Farcot, a well-known Paris constructor, has also furnished me with an account of his new motors and the accompanying views. Efficient air cooling is the main point he claims. In the 40-horse-power motor there are eight cylinders placed in V shape, with four on a side. He has calculated the amount of heat transmitted to the walls of the cylinders, and consequently the volume of air which is needed for the cooling. Not only has the air cooling the advantage of simplicity, but there is an increase of 10 per cent in the output of the motor; that is, so much less consumption of fuel. This is due to different causes, one of the principal reasons lying in the increase of temperature of the cylinders, which can be kept at 257 to 288 deg. F., whereas the water cooled motors often work as low as 110 or even 90 degrees. Another reason lies in dispensing with all sinuous passages and reducing the surface of the cylinders in contact with the gas by



RENAULT 45-HORSE-POWER AIR-COOLED MOTOR.

arranging the valves in chambers beside the dome-shaped heads and thus removing the exhaust valve (the cause of heating) as far as possible from the body of the cylinder. An improved form of valve is also employed here, as well as a new carbureter. We show a small motor of 10 to 12 horse-power, with two cylinders, weighing but 25 kilogrammes (55 pounds) in complete running order, including ignition, flywheel and fan, making 4.6 pounds per horse-power. As to the 40-horse-power motor, the air cooling is found to be very efficient. A large motor of 700 horse-power is in construction. This will weigh 650 kilogrammes complete (1,430 pounds), including the fan, magneto and carbureter.

THE RENAULT AIR-COOLED MOTOR.

The well-known automobile firm of Renault Frères has also brought out an 8-cylinder type of light-weight motor for aeronautic work. The eight cylinders are mounted upon a common crank-case, as shown in the illustration. The normal speed is 950 revolutions per minute. The cylinder bore is 90 millimeters (3.543 inches), and the stroke 120 millimeters (4.724 inches). The motor is designed for 45 horse-power. Its weight is 150 kilogrammes (330 pounds). As will be noticed, the cooling flanges of the cylinders are square instead of round. There are two fans, one at each end of the motor. A sheet-iron casing aids in giving a good draft. A magneto is used for the ignition, and all the valves are mechanically operated.

ANIMALS THAT ARE BLIND.

SOME LIVE IN CAVERNS, SOME IN OCEAN ABYSSES.

AN interesting group in natural history is that comprising the blind animals. Most of them live in caves. Others live concealed during the day under stones or are found in the gloomy abysses of ocean.

A striking peculiarity of most of the blind cave animals is that though no faintest ray marks the difference between day and darkness in the depths they live in, those whose ancestors were nocturnal in their habits still prefer to move about during those hours when the surface of the earth is in darkness.

Among the cave animals one of the most striking varieties is that of Amblyopsis. This fish was at one time abundant in the Mammoth Cave of Kentucky and in other cave streams in the central part of this country, but is now scarce, for some unknown reason.

Although the fish is entirely destitute of external eyes the optic lobes are as much developed as in fishes with perfect eyes. To compensate the animal for the loss of sight, which would be useless to it, nature has provided it with a great number of soft nipples arranged on transverse ridges on the head and provided with sensitive filaments by means of which it is enabled to seek its food solely by means of this exquisitely arranged sense of touch.

They feed quite largely upon one another and upon the blind crayfish and smaller crustaceans which inhabit the same waters. In color they are white, with a rosy tint. Despite their blindness they are said to make their way from one cave to another through the short, open streams which sometimes connect them.

Among other blind cave fishes found in this country are *Typhlichthys subterraneus*, *Troglichthys rosæ*, and three species of *Chologaster*. The first, which is found in the caves of Indiana, Illinois, Kentucky, Alabama and Tennessee, has a translucent, colorless body. Its mouth is directed upward, and as the head is very flat the fish receives its food from above, and as a result spends most of its life near the surface—a very wise provision of nature, as the greater part of the cave life is found there.

Chologaster has eyes in a primitive condition of development and has the color and structure of ordinary fishes. While not completely blind, it is very nearly so. It is common in the ditches and swamps of the Southern States.

In South America is found a small siluroid or catfish, called *preñadillas* by the natives, which has very small eyes covered with transparent skin. This species achieved some fame through the popular belief that they lived in subterranean waters within the bowels of the active volcanoes of the Andes and were ejected with streams of mud and water during eruptions. The real explanation of their appearance during volcanic eruptions is that they abound in the lakes and torrents of the Andes, are killed or stupefied by the gases escaping during an eruption and are swept down to the valleys below by the currents of water issuing from the volcanoes.

Two species of blind catfish are found in the cave streams of Pennsylvania, while many members of the same family which live in muddy waters have very small or even minute eyes. One of the gobies, which buries itself in the sand or is found under stones in the holes of a burrowing crab on the coast of California, is also blind.

Two long and very slender fishes, with the shape of eels, which are found in the fresh waters of certain caves in Cuba, are also blind. In the Indian Ocean is found an electric ray with sightless eyes, but curiously enough, the fish is provided with a row of minute luminous glands along the edge of its disk, these probably being lures to attract prey.

In the caves of Carinthia and Dalmatia, in Austria, is found a small batrachian called the olm. This animal has four legs, but its organs of vision are poor.

A very similar animal, only much smaller and with no trace of eyes except two black spots above the nostrils, was discovered in Texas a few years ago. As the United States Bureau of Fisheries was boring an artesian well at its San Marcos fish hatchery a cave stream about 190 feet below the surface was tapped, which shot up at the rate of 1,200 gallons a minute. With it came large numbers of these cave salamanders, also thousands of tiny shrimp-like blind creatures.

Among snakes there are four species on this continent which are practically blind. They are popularly known as "blind worms." They are the lowest as well as the smallest of snakes; an ordinary earthworm is gigantic when compared with some.

The cavern rat, found in the Mammoth Cave of Kentucky, is of a soft bluish color, with white neck and feet. It has enormous eyes, black as night, but quite unprovided with irises.

These eyes are insensible to light, and when the experiment has been made of catching a cavern rat and turning it loose in the bright sunlight it blunders about, striking itself against everything, is unable to provide itself with food and finally falls down and dies. In its native depths it is able to lead a comfortable enough existence, as its enormously long whiskers are so sensitive that they enable it to find its way rapidly through the darkness.

The principal food of the cavern rat consists of a kind of large cricket of a pale yellow color, and which, like most cave dwellers, is blind. The cavern beetle was first discovered some seventy years ago in an Austrian cave, the grotto of Adelsberg. One specimen only was caught, and though its discoverer offered a prize of $25 for another it was fourteen years before a second was found.

This insect has a little round body, very long legs and absolutely no eyes. Brought out from its gloomy haunts into the light of the sun, it dies almost immediately. Yet, in its home, far beneath the surface of the earth, it moves with great rapidity and certainty.

To make up for its lack of sight it is provided with antennæ of extraordinary length and delicacy. By means of these it feels its way over the rough surface and hunts its prey, other smaller blind insects, with great rapidity and absolute certainty.

The cavern beetle has its enemies also. The blothrus (a species of scorpion) and the great eyeless spider hunt it remorselessly.

Prince Khevenhuller, who thoroughly explored these caves some years ago, describes it as an extraordinary sight to watch by the light of a candle a scorpion, absolutely eyeless, hunting a beetle, equally blind, along the cavern wall. Although the beetle was several feet in front of the scorpion, and divided from it by a fissure in the rock, the scorpion tracked it with absolute and almost appalling certainty.

The spider found in these caves is of a lovely ivory white, and is able, like other insects which inhabit the same subterranean depths, to run very rapidly and find its way with as much certainty as if it had eyes and light to use them.

Instances of blindness among the crustacea are occasionally found. The most noted is that of the blind crayfish of the Mammoth and other caves of Kentucky and Indiana. The animal inhabits shallow pools with muddy bottoms. It moves slowly with its feelers spread out before it and gently moving to and fro, feeling, as it were, every inch of its way.

One of the most curious cases of degeneration among the crustacea is that of *Ethusa granulata*, one of the stalkeyed crustacea. In shallow water it is found with well-developed eyes. In deeper water, from 110 to 370 fathoms, eye stalks are present, but the animal is apparently blind, the eyes being replaced by rounded terminations to the stalks; in examples from 500 to 700 fathoms, in another locality, the eye stalks have lost their special character, have become fixed, and their ends combine into a strong pointed beak. In this case there is a gradual modification, depending apparently upon a gradual diminution and final disappearance of solar light.—The Sun.

THE WHALE-HUNTING INDUSTRY.

By FREDERIC A. LUCAS.

NOTHING is too large or too small to escape the notice of man, and nothing can ultimately hope to avoid destruction, provided "there is money in it." The smallest known vertebrate, a little fish of the lakes of Luzon, is a staple article of food, and the greatest of backboned animals, the sulphur-bottom whale, is being systematically swept out of existence by the most approved methods of destruction. One is more than three billion times as large as the other, but neither can escape the all-grasping and all-powerful hand of man.

Whaling has been prosecuted for upward of a thousand years. At one time or another it has been pursued by every important maritime nation and in every part of the world where whales were to be found in important numbers. But the capture of the larger whales as a regular thing is undoubtedly a comparatively modern occupation, for none of the weapons of primitive man indicates that he ever attacked anything larger than porpoises or the white whale, although the larger species may have been taken.

It is very likely that whaling had its inception in the dead animals cast up on the beach. The vast store of oil provided by one of these monsters naturally caused the fishermen to cast longing eyes on those sporting at a little distance, and to actually attack them was but a step, although a long one, for he was a brave man who first ventured to assail the largest of living creatures.

The whale fishery may be said to have traveled in a circle. It began with shore whaling, and after the lapse of centuries has returned to this method under changed conditions and with modern methods and appliances. Stations are being established all over the world wherever the conditions are favorable. It is probable that here again history will repeat itself, that in a few years whales will have become so scarce that the majority of whalers will go out of business, and that here and there whales will slowly begin to increase in numbers.

Meanwhile, it is a curious fact that though whales are so common in many parts of the world and have been killed in numbers for centuries, comparatively little is known of them and good pictures and reliable information are scarce. It is a case where the very size of the animal makes its study difficult, and those brought in closest contact have neither time nor ability, as a rule, to avail themselves of their opportunities, and naturalists have been obliged to depend on such specimens as were cast ashore.

As a result of this, the numbers of alleged species of whales were greatly multiplied, for each specimen that came ashore seemed to be just a little different from any other that had been described, and so a new name was bestowed upon it. And it is only within a few years that the web of names in which they were enveloped has been unraveled and they reduced to a few good species.

In the early days we find much misinformation in regard to these leviathans. Even modern textbooks give the length of whales as anything up to 150 feet, their weight as many tons, and their shape as almost anything. The extreme length reached by the sulphur-bottom or "blue whale," the largest animal that lives, or for that matter ever lived, is about 85 feet. Among the things modern whale fishing has done has been to make it possible for museums to exhibit these huge animals so that visitors may obtain a correct idea of their size and appearance and really know them better than those who go down to the sea in ships and do business in great waters.

The modern whaler is a trim iron steamer about 90 feet in length and 90 tons burden, capable of making 12 knots an hour and powerful enough to tow in two whales at once. This craft, which can relentlessly pursue a whale hour after hour, carries only two men more than an ordinary whale boat. It can easily kill and bring home three whales in a day.

The old method was to make fast to a whale, tire him out, a process that sometimes required hours of hard work and frequently great risk on the part of the boat's crew, and then kill him with a lance. After this the animal was usually towed laboriously to the ship by boats and quite as laboriously cut up by hand and made into oil. Steam and the whale gun have changed all this and largely destroyed the romance of whaling. There is little excitement save in the chase, which is often prolonged. The actual capture is usually a tame affair, and accidents are infrequent. Originally only the oil was used, and much of this even was wasted owing to the primitive methods employed. This was the case both in deep-water and inshore whaling, the huge carcasses being turned adrift after having been stripped of their blubber, a practice that has led to much profanity and many complaints on the part of fishermen and dwellers along the coast. Nowadays the flesh and bones are used for fertilizer, the viscera for leather, and scraps for glue, and the whole whale is used up in forty-eight hours.

* Abstracted from an address read before the Museum of the Brooklyn Institute.

AURORÆ AND MAGNETIC STORMS.

CAUSED BY SOLAR DUST IN THE EARTH'S ATMOSPHERE.

BY SVANTE ARRHENIUS.

MANY of the particles which are thrown off by the sun penetrate the earth's atmosphere, and there give rise to various phenomena. The peculiar luminescence which is exhibited by the sky on clear nights is caused by discharges of electricity from these particles, and many puzzling phenomena of the aurora, which is now believed to be due to electrical discharges in the upper atmosphere, can be explained by the presence of this solar dust.

The observed fact that meteors are heated to incandescence at heights exceeding 100 miles proves that the atmosphere possesses an appreciable density at such heights. Particles so fine that the rapid loss of heat from their relatively large surfaces prevents their being heated to incandescence must be suspended at still greater heights, for which we may assume a mean value of 250 miles.

Some of these particles expelled by the sun are electrified either positively or negatively, and these alone are concerned in the production of auroræ. The unelectrified dust falls slowly to the earth's surface and constitutes a small part of the annual accretion of 20,000 tons due to the impact of meteors from all sources.

The solar particles bring with them gases condensed from the chromosphere and the corona, chiefly hydrogen and gases of the helium group. These gases are found, in very small quantities, in the earth's atmosphere, the occurrence of hydrogen in which is regarded by Mitchell as strong evidence for the penetration of the atmosphere by solar dust, for any hydrogen originally present must long ago have combined with oxygen. Hydrogen is discharged by Kilauea and some other volcanoes, but it is consumed when it comes into contact with the air.

The influx of solar dust varies with the eruptive activity of the sun. Dust betrays its presence in the atmosphere by its effect on the color of sunlight. The eruptions of Krakatoa and Mont Pelée were followed by a red glow caused by volcanic dust. But dust produces another effect, which can be measured. In general, the light of the sky is polarized, but unpolarized light is emitted at sunset by a small region, known as Babinet's point, about 20 degrees above the sun, and also by Arago's point, above that part of the horizon opposite the sun, and the height of these points increases with the quantity of dust in the air. Now Burch has found that these heights are approximately proportional to the solar activity, as indicated by the number of sunspots.

When the air contains much dust and is also strongly ionized by cathode rays, conditions are favorable for the formation of clouds. For example, auroral discharges are regularly accompanied by characteristic cloud formations. Klein has traced the connection between the number of sunspots and the frequency of high cirrus clouds from 1850 to 1900, and has found simultaneous maxima and simultaneous minima for the two phenomena.

A similar effect has been observed on Jupiter, which appears lighter in hue in sunspot maxima, owing to the formation of clouds, and deep red in sunspot minima, when the glowing body of the planet is less thickly veiled.

Auroræ or "northern lights" are caused by the discharge of electrified solar dust in the earth's atmosphere. They occur with maximum frequency along an irregular line which skirts Nova Zembla and Norway and passes south of Iceland and Greenland, across the middle of Hudson's Bay and the northwestern part of Alaska. In Lapland they occur five times oftener than in Stockholm, and thirty times oftener than in Berlin.

Paulsen divides auroræ into two classes. Those of the first class are widely extended, quite steady, and show no streamers. In general they rise slowly toward the zenith and do not affect magnetic needles. The aurora of this type usually appears in the form of an arch, or of a number of arches. Extended regions of the Arctic sky often glow with a faint light, like translucent clouds. Sometimes these luminous masses are so near the ground that they appear in front of hills not more than 1,000 feet high.

In northern Finland Paulsen observed the line characteristic of auroræ in the spectrum of the light emitted by the air between the spectroscope and a black cloth a few yards distant.

Auroræ of the second class are distinguished by characteristic streamers or rays, either sharply separated or blending at the bottom and presenting the appearance of curtains flapping in the wind. The rays are nearly parallel to the dipping needle and, when seen in perspective, appear to diverge from the center of a radially striped "corona." Auroræ of this class are not steady, but are traversed by a series of waves of luminosity. As they rise from the northern horizon they deflect the north pole of the compass to the east but after passing the zenith they cause a westward deviation. Hence Paulsen infers that the streamers are cathode rays in which negative electricity moves downward. Auroræ of the first class are more akin to phosphorescence, involving little movement, but the two types often quickly succeed each other.

The radiate auroræ closely follow the eleven-year sun-spot period. In a year of minimum spot frequency the coronal streams of negatively charged particles have small velocity. Hence the coronal rays emanating from the sun's poles are deflected by the solar magnetic force to the sun's equator. Here the magnetic force is weaker, so that the particles are expelled by radiation pressure in a plane sheet parallel to the sun's equator. Some of this dust reaches the earth where it is divided by terrestrial magnetic action into two streams, directed toward the earth's magnetic poles. As these poles are at some distance beneath the surface, the particles strike south of the north magnetic pole when it is noon at that point. Similarly, when it is midnight at the magnetic pole most of the particles strike before they reach even the geographical pole, which lies in their way to the magnetic pole. Hence the negatively electrified dust is concentrated in a ring which includes the magnetic and the geographical pole, and here its impact on the air molecules produces the phosphorescence of the auroræ of the first class.

In a year of maximum sunspot activity, on the contrary, the coronal rays are shot forth in all directions with such velocity that they are little affected by either solar or terrestrial magnetism, and hence they may cause auroræ far beyond the Arctic circle. The frequency of such auroræ, due to these "hard" rays, is proportional to the number of sunspots, but the phosphorescent auroræ, which are confined to the Arctic and Antarctic zones and are due to the "soft" or slow rays, are most frequent when sunspots are few.

Besides the eleven-year period, several others can be traced in auroral phenomena. There is an annual periodicity which is easily explained by the solar dust theory. Sunspots and faculæ seldom appear at the solar equator and are most abundant 15 degrees from the equator. The plane of the solar equator is inclined 7 degrees to the plane of the earth's orbit and passes through the earth on December 6 and June 4. In accordance with these facts we find, in general, auroræ most frequent in March and September and fewest in December and June.

The period of twenty-six days, which affects auroræ, terrestrial magnetism, thunder storms and barometric pressures, has long been ascribed to the sun's rotation. It is now known, however, that the period of this rotation varies with the solar latitude, from 27 days at the equator to 43 days at 75 degrees. Even the equatorial period is shorter than the auroral period but it applies only to the photosphere. The equatorial spots, above the photosphere, rotate more swiftly and the still higher faculæ have a period of about 26 days. The particles which cause auroræ are formed above the faculæ where the radiation pressure is strongest.

The theory that the solar radiation is most intense in times of the greatest development of sunspots is confirmed by some measurements of terrestrial temperatures and apparently contradicted by others. But the latter were made in tropical and other regions where the observed lowering of temperature was probably due to the formation of clouds. In very dry regions rise of temperature coincides with sunspot maxima and the conditions existing in high atmosperic strata, above the clouds, must be similar to those of a desert.

A daily period and one equal to a tropical month (27.3 days) have also been traced but are difficult of observation.

The effect of auroræ on the compass has been known since 1741. The magnetic disturbances show all the periods that have been observed in auroræ and sunspots. The greatest disturbance is in the declination, but both the dip and the horizontal intensity are also affected.

The ultra-violet rays of the sun are strongly absorbed by the atmosphere and they ionize the air, particularly at great heights. Water vapor brought by ascending air currents is condensed chiefly upon the negative ions. Hence most clouds are negatively electrified. After a rainfall the air is positively charged, as aeronauts have proved. Clouds formed at the greatest heights are the most strongly charged, hence thunderstorms are most frequent in summer.

The mean interval which elapses between the meridian passage of a sunspot and the maximum magnetic disturbance is about 44 hours, according to Ricco. This corresponds to a mean velocity of 945 kilometers (587 miles) per hour. Now a drop of water 0.00016 millimeter (1/160,000 inch) in diameter (the size of maximum velocity) expelled from the sun by a radiation pressure equal to 2.5 times the solar gravity, would reach the earth in 56 hours, traveling with a mean velocity of 740 kilometers (460 miles) per hour.

If the solar particles consist of hydrocarbons, mixed with hydrogen, helium and other gases, their density would, not improbably, be two-thirds that of water, and they would accomplish the journey in 44 hours. Still higher speeds would be attained by particles of the spongy carbon, iron and silicates of which meteorites are chiefly composed.

The electrical phenomena of the atmosphere are of great importance to man and organic life in general. Electric discharges effect the combination of atmospheric nitrogen with hydrogen and oxygen, and thus produce the ammoniacal salts, nitrates, and nitrites required for the growth of plants. Ammonia appears to be produced especially by silent discharges, like those of the aurora, while the nitrates, which are most abundant in the tropics, are formed chiefly in thunderstorms.

The quantity of combined nitrogen thus produced and washed down by the rains amounts to 1.25 grammes per square meter (about 11 pounds per acre) in Europe and nearly four times as much in the tropics. An average deposit of 3 grammes would give an aggregate of 400 million tons for the entire land surface of the globe. Only five per cent of this falls on cultivated land, but the rest quickens life over mountain, forest, and steppe. The Chile saltpeter mined in 1905 contained only 260,000 tons of nitrogen and a fourth as much was produced by European gas works. Even with the addition of the American product artificial nitrogenous fertilizers do not amount to one-thousandth of the quantity furnished by nature.

Yet only one three-millionth part of the nitrogen of the atmosphere is thus combined, annually, and most or all of this returns to the atmosphere, for no notable accumulation of nitrogen has been found in the earth. For comparison it may be noted that one part in 35,000 of the oxygen and *one fiftieth* of the carbon dioxide of the atmosphere pass annually through vegetable organisms.

In conclusion, brief mention must be made of the peculiar phenomenon called the zodiacal light which in the tropics appears for a few hours after sunset and before sunrise on every clear night. In the temperate zone it is seen rarely, generally at the equinoxes. It is usually described as a luminous cone with its base at the horizon and its axis directed along the zodiac. In the tropics it is about as bright as the Milky Way and gives a continuous spectrum.

There can be no question that this light is sunlight reflected by particles of dust and this dust has been believed to form a ring around the sun and to be a remnant of the primordial nebula of the Kant-Laplace hypothesis.

Occasionally a faintly luminous band (Gegenschein) extends along the ecliptic from the apex of the cone and broadens into an ill defined spot near the horizon, opposite the sun. The spot and band probably represent a stream of particles falling toward the sun, their apparent positions being the effect of perspective.

Very little is known about these phenomena. Even the position of the zodiacal light is uncertain, and recent observations indicate that it lies in the plane of the sun's equator. But it is generally believed to be due to particles moving from, toward, or around the sun and hence we have another indication of the abundance of solar dust and the probability that it may afford an explanation of the phenomena described in this article.—Abstracted from "Das Werden der Welten," Chapter V.

An Osaka paper states that aside from two torpedo craft recently ordered by Governor Chang-chi-tung in Japan, and already delivered at Wuchang, an order for twelve other warships of different types has now been placed in Japan by China.

ELECTRICAL NOTES.

There seems to be no doubt that in the very near future all the railroads of Sweden will be changed over to the electric system. The experiments which have been carried out within the last year on the Stockholm-Jarfva section which is specially equipped for the tests and using single-phase electric locomotives, have abundantly proved the good working of the electric system, and it is very likely that the first step will be to apply it to a certain extent of railroad and then increase this in the future. In 1906 the Swedish Parliament allowed a credit of $1,500,000 in order to begin the important work of reorganizing all the railroads in the country and to purchase the hydraulic rights which would be needed for the preliminary part of the work. To this end the State has already acquired a number of falls which are to be used for working the first sections of railroad. At present the locomotives of the Swedish railroads are using imported coal, and as this has a relatively high price, there will be a decided advantage to be secured from the use of hydraulic power. This is very abundant in Sweden, and there have already been erected a number of large turbine plants by private companies. Among these the new Trollhattan plant will be one of the largest in Europe, as it will give 80,000 horsepower when completed. It is to furnish current for the city of Gothenburg. On the other hand, the Lagan falls are utilized by a company which is expending $2,000,000 in the hydraulic work at this point. As regards the government railroad project, the engineers estimate that for all the lines in the country the hydraulic plants and pole-lines alone would cost nearly $20,000,000, but the running expenses of the road would give a good profit over the use of coal.

J. Larmor and C. V. Burton in Nature, referring to the objection to identifying magnetic force with velocity of the ether, which has been discussed by O. W. Richardson, O. Lodge, and others, Larmor observes that such a hypothesis involves that the all-pervading ether shall be at rest under normal conditions. An infinitely extended ether postulates absolute motion as a fact in the only real sense of that term, viz., motion relative to the remote quiescent regions of the ether. The point raised by Richardson, that the steady field of a uniformly moving electron would contain an infinite amount of moment of momentum, requires detailed consideration, but it is not without parallel in more familiar departments of abstract physics. For instance, in the case of the steady motion of a solid sphere in infinitely extended viscous fluid, the field of flow around the sphere contains an infinite amount of linear momentum. But this circumstance does not vitiate the dynamics of fluid resistance. In the case of an electron set into steady translatory motion through the ether it is rotational momentum which is steadily imparted to the surrounding ether as time goes on, and is carried away into the distant regions by wave motion. This requires that the ether exerts a torque on the moving electron. Burton remarks that if for the free ether it is assumed that magnetic force is within a constant factor identical with ethereal velocity, then the velocity of the ether at any point can be determined by measuring the magnetic force at that point. For the value of the magnetic force there is a perfectly definite physical criterion, which is independent of any arbitrarily chosen frame of reference, and hence the means would be afforded of determining absolutely the velocity of the ether. Thus, on the assumption, absolute motion attains to a definite physical significance which has no counterpart in the postulates of ordinary dynamics, and, this being so, dynamics must fail to give a true account of electromagnetism. Thus, if the magnetic vector be identified with translational ethereal velocity, and at the same time it is assumed that a dynamical system is being dealt with, results inconsistent with known electromagnetic relations may be expected.

In the Electrical Review a description is published of the smelting and refining plant at Tacoma, Washington, recently completed for the Tacoma Smelting and Refining Company. This plant treats copper and lead ores containing down to 1 per cent of pure metal, and earns a profit on the results. The raw ores are drawn from the mines of British Columbia, Alaska, California, Oregon, Mexico, South America, and Europe, and over thirty varieties have been roasted in the Tacoma smelter. The skill used in mixing the ores is one reason why it has been made profitable to work such low grades. The concentrate furnace in the copper plant is of the Allis-Chalmers type, and has a maximum capacity of 350 tons per 24 hours. The metal obtained from this furnace is run into ladles, and taken directly to the converting department, where it is run through a cupola, and then blown in a tilting converter. The process used is similar to that used for Bessemer steel, and the product remaining is crude copper with a high percentage of impurities. This copper is next cast into anodes, the furnace used for this work being of the rotary type and heated by oil fuel. The anodes weigh each 125 pounds and from 20 to 24 days are required to work them down in the electrolytic vats. The kathodes and anodes are set in the vats with a clearance of only 1 inch. Each vat takes a charge of 18 anodes and 19 kathodes, a traveling crane of 20 tons capacity being used to charge and discharge the vats. The electrolyte is a solution of copper sulphate containing 16 per cent of this salt and about 5 per cent free sulphuric acid. The vat slimes containing the silver and gold are treated with a 25 per cent solution of sulphuric acid, and are then dried and worked up for the noble metals in the lead refinery. A current density of from 10 to 15 amperes per square foot is employed in the copper depositing vats, but this is varied according to the amount of silver and arsenic present in the anode copper. Less than ½ volt per vat suffices to distribute this current through the refinery. The current is brought to this department by 10 cables, and is transformed from 40,000 volts, the pressure at which it is transmitted from the generating station 40 miles distant in the foot-hills of Mount Rainier, to 100 volts—the pressure at which it is used in the works. A noteworthy feature of the works is the slag-casting machine attached to the concentrate furnace. This machine is of the circular type, is provided with 144 tilting molds, and has a total capacity of 20 tons. The Tacoma works utilizes about 2,000 horse-power in the various departments, and has a daily output of from 30 to 43 tons of copper.

ENGINEERING NOTES.

According to the American Machinist, a plan of shop apprenticeship that is in operation in one large sheet metal workers' establishment in Philadelphia provides for a bonus to be paid to the apprentice upon completion of his term of indenture. The apprentice is started at a wage of $5 a week, which is increased $1 at the end of each six months during a period of four years. In addition to this, his employer deposits in a fund $1 each week during the entire period, making a bonus of $208 with accrued interest. It is understood that this $1-a-week bonus is not in any sense part of the boy's wages, but is offered as an inducement for him to serve his term faithfully. The agreement is made with the boy's parents and provision is made that the amount deposited will be forfeited upon failure of the apprentice to observe the agreement.

In a thesis presented to the Lewis Institute, Chicago, the effect of steam curing on the crushing strength of concrete is considered. The steam treatment consisted of immersion of the blocks, 24 hours after molding, in a steam bath generally under about 2½ pounds per square inch pressure. The mixture was 1:3:4½. It is concluded that steam-treated concrete receives its primary set sooner than if not treated. If the steam treatment be not followed by any further treatment, the strength acquired in the course of time by the concrete is not so great as that of concrete allowed to set primarily in air and then kept moist. With less than 24 hours' steam treatment the treated concrete is the stronger during the first week. If, however, steam-treated concrete be subsequently kept moist, its strength both primarily and ultimately is greater than that of corresponding non-treated material. The strength of steam-treated concrete increases with the duration of the steam treatment. Results are also given for different pressures and with additions of CO_2 to the steam, but these are too limited to allow of general deductions.

The Automotor Journal states that experiments were recently carried out with wind screens attached to a Napier racing car. The nineteen screens varied from 2 to 30 square feet in area, the area being generally an uninterrupted surface, and the speed of the car varied from 48.9 up to 79.0 miles per hour. Air resistance is generally taken to be AV^2 pounds per square foot, A being a constant and V the speed in miles per hour, and A has been variously given as 0.005, 0.00365, and 0.0017 (adopted by the Royal Automobile Club). In the tests referred to, the car was run at as high a speed on the Brooklands racing track as each screen would permit. From horse-power and efficiency tests previously carried out at the works, it is deduced that a draw-bar pull of 36.1 pounds was required to overcome tractive resistance, and that 249.6 pounds were available for forcing the car through the air. A point of uncertainty is the cross-sectional area that should be allowed for the car and driver. Three sets of results are worked out, taking this at 10, 12½, and 18½ square feet respectively; actual measurement gave 12½ square feet. The numerical results are given and plotted, and from the curves it is seen the constant A decreases as the area of screen increases in the first two cases, but is fairly constant in the neighborhood of 0.0022 when 18½ square feet is taken for the car area. The article concludes, however, that 0.003 is a reliable figure. The curves do not show a tendency to approximate to the same figure for the larger screens, though the divergence is less than with the smaller screens.

SCIENCE NOTES.

The rare phase of Venus as a luminous ring was observed in 1898, and again at the conjunction of 1906. On November 29, 5h. 7m. G.M.T., the planet was observed with the 5-inch finder of the 23-inch telescope at Princeton University by H. N. Russell and Z. Daniel. It was then about 1 deg. 49 min. from the sun. When the complete circle was visible the space within it always appeared a shade darker than that without, but it is likely that this was subjective. The extent of the crescent was measured with a filar micrometer on November 27 and December 4, and the value of the twilight arc in the planet's atmosphere found to be 58 min. on November 27, and 62 min. on November 29, agreeing fairly well with the mean value of 70 min. determined from the 1898 observations. The ring phase of Venus may perhaps be seen again in 1914 if the atmospheric conditions are very favorable, after which there will be no further opportunity until 1972.

R. Marc has already shown by two independent methods that gray crystalline selenium exists in two distinct polymorphous forms, A and B; A is a non-conductor, B a good conductor of electricity. The transition from the A form at 140 deg. to the B form on heating to 200 deg. has now been observed microscopically. It has also been found that there is a difference in the solubilities of the two modifications; B is probably rather less soluble in carbon bisulphide than A. The equilibrium mixture at the ordinary temperature is sensitive to light, which displaces the equilibrium from A to B just as does rise of temperature; the action of the light is, however, a photochemical and not a calorific effect. The author makes the following recommendations for those interested in the construction of sensitive selenium cells: (1) An addition of 0.1 to 0.5 per cent of silver or other efficient catalytic agent; (2) the complete transformation (preferably in an oxygen-free atmosphere) at 200 deg.; this can be best traced by the use of a galvanometer; (3) the establishment of a complete equilibrium at the ordinary temperature; (4) the employment of as thin a film of selenium as possible; (5) the arrangement of the electrodes should be such that the rays of light fall upon the places of greatest current density; (6) access of moisture is to be prevented.

Skinner has found that most metals, when used as the kathode in a discharge tube, give off hydrogen. This shows that metals in their natural condition contain a certain amount of absorbed hydrogen. In the research undertaken by W. Heald (Phys. Zeitschr.) the discharge tube used was cylindrical, the electrodes being screwed or riveted on to the ends of brass rods which were cemented in glass tubes ground into the ends of the discharge tube. The latter was connected up to a pump through a drying tube, and also could be connected to a flask containing dry hydrogen. Before filling with hydrogen the tube was left for some time exhausted and in connection with the P_2O_5 tube. For fusing the metals a current from a battery of small accumulators was used, the voltage being about 1,000 volts. The tube was filled with hydrogen at a pressure of 1 to 6 millimeters and then the current sent through to heat the electrodes. The pressure was measured by means of a sensitive McLeod manometer. The metals were heated up to fusion and afterward time readings of the pressure were taken, the fall in pressure being due to absorption of hydrogen by the metals. The metals experimented on were Cd, Ag, Zn, steel, Al, and Pt; of these Cd, Ag, and steel give results which indicate slow absorption. In the case of Al and Pt, the pressure rose after the heating; it is probable that for these metals the absorption is so rapid that the metals are saturated before the pressure can be observed. Zinc is the only one of the metals investigated which shows no absorption.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Gasoline Motors for Aeronautical Work.—6 illustrations ... 25

II. AGRICULTURE.—A New Agricultural Oil Motor.—4 illustrations ... 26

III. ASTRONOMY.—Aurorae and Magnetic Storms.—By SVANTE ARRHENIUS ... 31

IV. CIVIL ENGINEERING.—Reinforced Concrete Engineering.—By ALBERT WELLS BUEL ... 25

V. ELECTRICITY.—Experiments with Electrical Treatment of Boiler Water on the El Paso and Southwestern Railway System.—By J. L. CAMPBELL ... 26
Glass Telegraph Poles ... 26
Electrical Notes ... 26

VI. ENGINEERING.—Engineering Notes ... 26

VII. GEOLOGY.—Natural Gas Production in 1906 ... 26

VIII. MECHANICAL ENGINEERING.—The Gas Engine Cycle.—By W. H. BOOTH ... 27
Progress with Ball and Roller Bearings ... 24

IX. MISCELLANEOUS.—Target Practice at an Old Battleship.—5 illustrations ... 27
Keeper of the King's Seal ... 27
Diptychs ... 27
The Wood Famine ... 27
Science Notes ... 27

X. PHYSICS.—Recent Radium Investigations.—By Sir WILLIAM RAMSAY, K.C.B ... 27

XI. TECHNOLOGY.—Tannery Wastes ... 27
Silvering Glass.—By E. C. C. BALY ... 27
Working up Old Printed Paper ... 27

XII. ZOOLOGY.—The Whale-hunting Industry.—By FREDERICK A. LUCAS ... 27
Animals That Are Blind ... 27